INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, June, 1923 *Number 6*

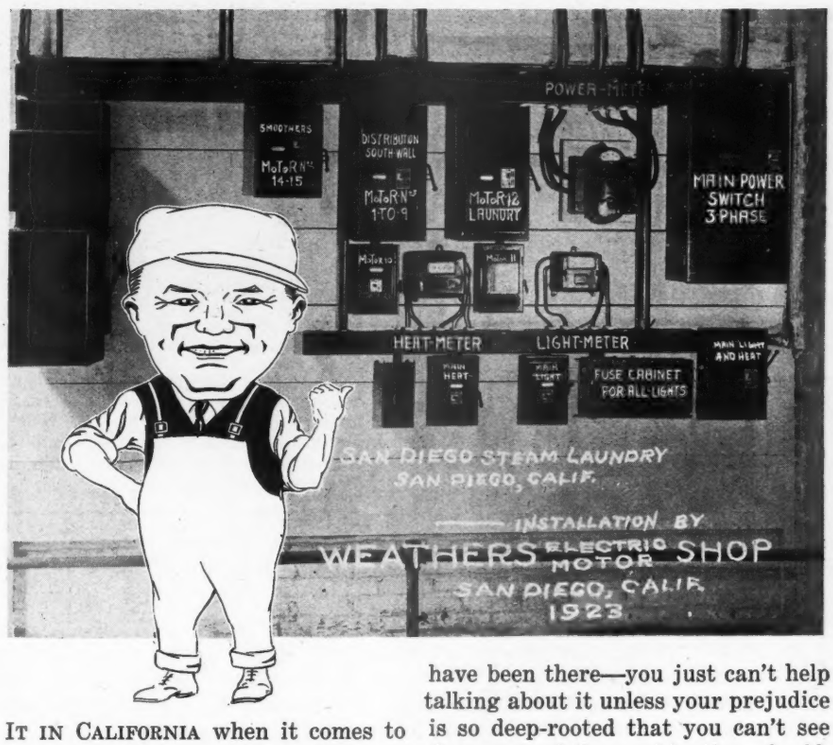
How They Do It in California

And some reasons why everybody likes to talk about the things they do there.

THOSE WHO have never visited that state of flowers and golden sunsets in the empire west of the Rockies have a real treat coming. Californians like to talk about their state, its natural resources, its golden opportunities and particularly do electrical men like to refer to the fact that California leads all the states of the Union in kilowatt-hours used per capita. And well may they brag of the electrical development already there and certain to come in larger proportions.

Two years ago I had the pleasure of visiting by automobile the huge hydro-electric stations in the high Sierras and following the transmission lines they feed down into Fresno, the San Joaquin Valley, through Bakersfield and its oil well districts over the Tehachapi Pass into Los Angeles, the city whose count of 576,673 natives and non-residents is now of argumentative interest to the 506,676 people of San Francisco. All along this route are the unmistakable evidences of industrial and commercial development due to the harnessing of waterpower. But of particular interest is the extent and modernness of the electrical installations. In this section electrical energy is the recognized source of not only light and power, but heat as well.

The photograph shown here is one of several sent to me a little while ago by E. W. Weathers, proprietor of the Weathers Electric Motor Shop of San Diego, California. In a letter he said: "Believing that you might be interested in HOW WE DO IT IN CALIFORNIA when it comes to power wiring, we are sending you several pictures of some installations made during the past two years. Notice the main distribution system with its light, power and heat meters and the flexibility made possible by the trough connection for conduit instead of nipples. We are strong advocates of this trough connection."



You men from Maine southward to the Gulf and westward to the Rockies please take notice that Mr. Weathers says "We" all through his note and when he mentions California he puts everything in capital letters. This is the spirit of the empire west of the Rockies where everybody is a booster for what "We" — meaning the whole crowd, friends, enemies, just everybody—are doing to make that section what it ought to be and to let everybody know about it.

This kind of co-operative boosting is catching—if you don't believe it go to California and stay awhile. When you return your friends will know much more about the section and they will be certain that you have been there—you just can't help talking about it unless your prejudice is so deep-rooted that you can't see the power of the combination of self-interest and civic pride that is building the Pacific West by leaps and bounds.

But after all, in staid old New England and among the steel centers of the Middle West the same kind of electrical progress is going on. Somehow it is accepted as a natural course of events and those who are responsible for it have to be questioned long and earnestly to drag out the facts.

Now it seems to me that we can all learn a lesson from the Californians — not particularly Mr. Weathers, for he's fairly modest — but from all of them. Let's get that group-spirit of boosting everything that is good and correcting that which is bad.

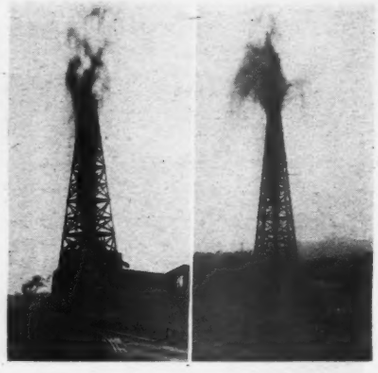
Practical Pete

A Glimpse Into the Works of the

Standard Oil Company

Which makes the crude petroleum of Mexico or Kansas usable and available to run automobiles or lubricate machinery. This is the sixth of a series devoted to the growth and extent of basic American industries.

PETROLEUM enters into our daily life under the guise of at least 250 different and marketable commodities. The crude oil of Mexico, Kansas, Texas, California, and of the old Pennsylvania oil fields must be taken to a refinery and transformed into a product to fit our needs. Crude petroleum in its original form can be used for but little more than fuel. Our needs demand naphtha for cleaning, gasoline for automobile engines, kerosene for fuel, paraffin, tar, asphaltum, and the numerous grades of lubricants from those suitable for sewing machines to the hard greases for big bearings, and a large number of other products. One of the big problems of the petroleum industry is that of transportation—from Mexico to the filling station where we get our "gas," or to the dealer who supplies our lubricants. Transportation charges alone, if the material were shipped this distance in small lots, would probably be more than is paid for the product in its finished state.



Gushers are the spectacular features among the oil wells, as the oil is under sufficient pressure to force it up in the air much higher than the derrick. These two gusher wells are located in Mexico.

Another problem of the industry is that petroleum refines into definite products. However, there is a greater demand for some of these products than for others. For example, at one time the greatest demand was for kerosene, with an unusable surplus of gasoline. The advent of the automobile and of gasoline stoves changed this demand until now more gasoline is used than kerosene. By the discovery of a "cracking" process the heavier oils which remain after the gasoline is removed are broken down

This elevation view, which extends onto the opposite page, shows the extent of the Standard Oil Company's plant at Bayonne, N. J.

Oil is received here by pipe lines from the wells in the interior of the United States and from Mexico by tank ships. When refined, it is reshipped to all parts of the world. Here are shown the agitators for treating naphtha, gasoline and kerosene, the paraffin plants, stills and filters while near at hand are plants for coke, fuel oil, asphalt and tar. There is also a plant for making the sulphuric acid used in refining. Five hundred steel and 6,000 hardwood barrels are made daily, besides 100,000 5-gal. tin cans for exporting oil and 50,000 wooden boxes to carry them.

In contrast to the gushers shown on the opposite page, most oil wells must be pumped.

This shows the oil wells on a 160-acre oil lease in Kansas. Pipe lines extend from the Kansas oil fields to Whiting, Ind., at the southern end of Lake Michigan, through which the oil is pumped, thus making it unnecessary to ship the crude oil in tank cars. Booster pumping stations are distributed along the line at frequent intervals. It is estimated that 75,000 tank cars and 900 engines would be required continuously to handle the oil moved in the United States by pipe lines alone. This is one method of reducing transportation costs, as on an average a barrel of crude oil travels 1,000 miles to the refinery.

under heat and pressure into more volatile products, including gasoline, and in this way a larger amount of gasoline is made from petroleum. This and other special processes developed in the industry have helped maintain the balance of production against demand. These demands, however, have not been altogether natural, but have in many cases been created through educational programs and extensive advertising which have made "Vaseline," "Polarine" and "Nujol," among many other products, well known the world over.

Petroleum refining industries are listed as seventh in value of manufactured products in the 1919 census. In this industry the largest item of expense is cost of raw material, which is about three and one-half times the cost of manufacture. In the meat packing industry and also in the flour milling industry which have been discussed in this series this same condition exists but with a ratio of about seven to one. Although each of the three stands high in the rank of industries according to the total value of manufactured products, none of them stands very high in the number of wage earners employed. However, extremely large investments are required to carry on each of these businesses.

Until 1859 petroleum had been taken from shale, which gave a scant supply at a high price. It is interesting that attention is again being directed toward the recovery of petroleum products from shale. Edward L. Drake was convinced that he could get oil out of the ground by drilling a well and drove a shaft near Titusville, Pa., where he struck oil at a depth of 69 feet on Aug. 29, 1859. At the announcement

A view of the double-drum pressure stills, for "cracking" the heavy ends of the oil under various degrees of steam pressure.

The largest demand of production is for gasoline. Under former methods of refining, only a definite amount of gasoline was obtained. In answer to the increased demand, processes were invented which "cracked" a part of the heavier oils into the lighter, more volatile gasoline. Obviously, fire is one of the biggest hazards of this industry.

of this news there was a rush to the oil field similar to the stampede for California gold ten years before. The demand for kerosene was so great that it sold for $1 a gallon. The methods of distilling and distributing were, however, crude and wasteful. Little refineries were set up near the wells. Thousands of gallons of gasoline were thrown away because it had no use. It is astonishing to learn that as late as 1897 there were 6,000,000 gallons of gasoline in Bayonne, N. J., which could easily have been bought for 5 cents a gallon. In about 1900 when the automobile began to come into general use the consumption of gasoline outstripped kerosene. In 1919 about 3,426,000,000 gallons of gasoline, 1,397,000,000 of kerosene, 6,290,000,000 gallons of fuel and gas oil and 568,000,000 gallons of lubricants were sold in the United States. In addition to this large quantities were exported.

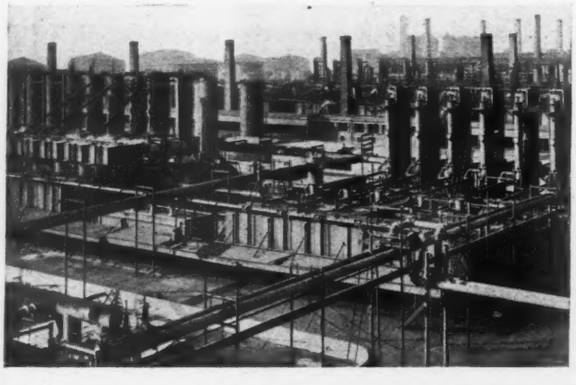
In the early '60's, when all operations connected with oil production were still imperfect, John D. Rockefeller, then a youth of twenty-one years, with two partners went into the oil business in Cleveland, Ohio. Their partnership prospered and near the close of this decade the Standard Oil Company was formed as a development of the partnership. The company then invited others to combine with it and in 1870 the Standard Oil Company of Ohio was organized with a million dollars capital. The Standard Oil Trust was organized in 1882, but was dissolved by the Supreme Court into thirty-four companies in 1911.

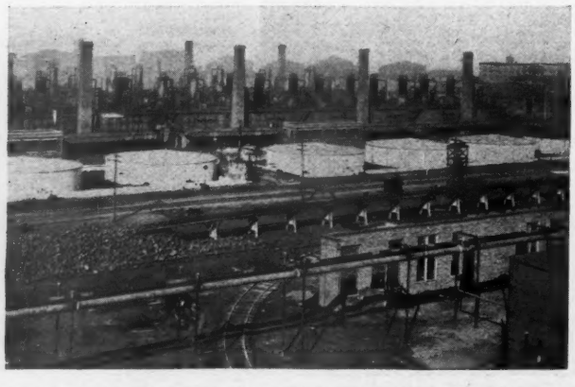
Crude petroleum yields four main products: (1) gasoline, naphtha and benzine; (2) kerosene; (3) lubricants, and (4) fuel oil. The innumerable by-products include vaseline, paraffin, road oil, asphalt, and petroleum coke. These are distilled out one after the other and each must be refined before it is usable. Care must be exercised in distilling that temperature and pressure do not get too high. Fire is one of the big hazards.

The main processes required are: (1) Getting the petroleum from the ground; (2) carrying it to the refineries; (3) refining it, and (4) distributing the products to the user. The first pipe line was laid in 1865. By 1911 the Standard Oil Company had 10,000 miles of trunk pipe lines and 80,000 miles of branches.

The refinery at Bayonne, N. J., shows strikingly the size, the multiplicity of operations and the diversity of products of the Standard Oil Company. Six thousand men and women are employed at this plant. In addition many thousands are employed in obtaining the wide distribution of the products of petroleum.

A general view of the first battery of crude, steam stills are shown in the foreground. The illustration at the right shows the rear of the third and fourth batteries of crude stills with the coke trestle in the foreground. The main storage tank field may be seen in the distant background.





Some Ways in Which

Shutdowns Have Been Prevented

During a Period of Nine Years by the Strict Application of a Common-Sense Maintenance Plan

By E. S. LINCOLN
Consulting Industrial Engineer, Portland, Me.

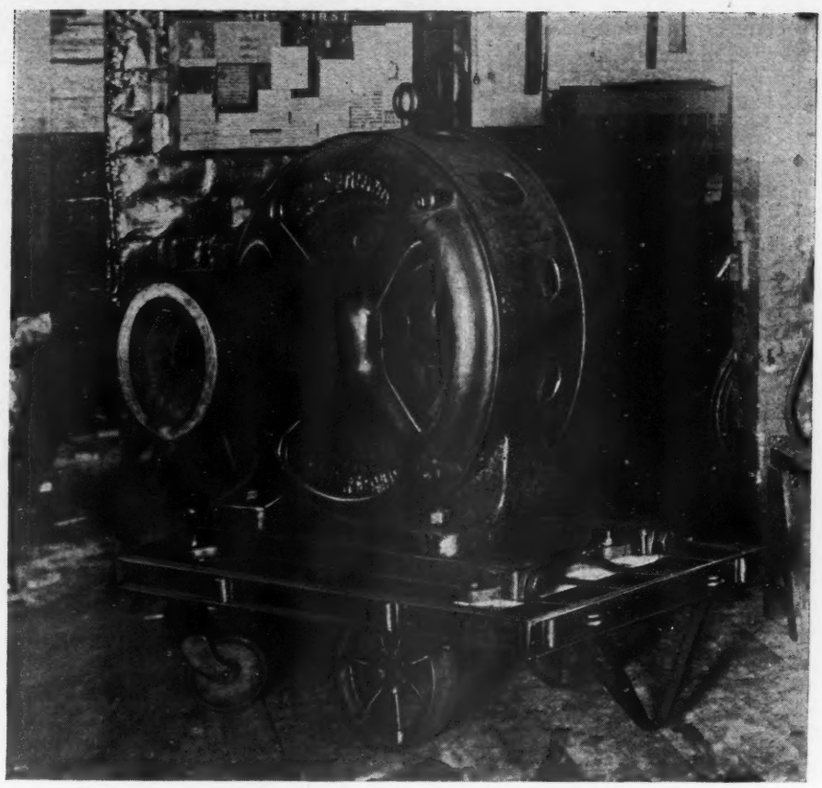


Fig. 1—This motor is kept on its small truck ready to be moved in a hurry.
Three large motors are equipped in this way to replace motors which break down or show signs of serious trouble.

A METAL-STAMPING plant does not offer electrical equipment a peaceful life. The variable loads, the high temperatures, the fumes and grit create troubles of various sorts. However, proper attention to installation and maintenance procedure will prevent most of these troubles as it has done for the Bossert Corporation at Utica, N. Y. In this plant no serious interruptions have been experienced for a period of nine years. Several burnouts have occurred where motors were purposely overloaded in order to increase production temporarily, but this has happened only a few times.

The secret of this freedom from trouble is frequent and thorough inspection and the fact that repairs are made at once and the plant always kept in good operating condition. Another reason is that the original installation was scientifically designed, and the construction work was carefully carried out by experienced electrical men.

Electrical energy is used in this plant for general power purposes, for electric welding, and for lighting, electroplating and miscellaneous uses such as operating cranes, industrial trucks, electric tools, and so on. The loads are variable especially when the large presses are in use and only a small portion of the load is in any way steady, with the result that the power factor is very low and variable. Furthermore, the continual expansion of the business requires a large amount of installation work. Changes in production from one article to another require considerable temporary work which is hard for an electrical department to take care of along with its regular duties.

Some Bad Operating Practices That Have Been Stopped

A comparison between the company's original electrical system and that in use today will give an idea as to what proper installation and a competent electrical department have done to assist in improving the plant production. Ten years ago this corporation had in use about sixteen motors ranging from 1 hp. to 100 hp. and a very small amount of other electrical equipment. No regular electrician was employed and the company did not have a plan for maintenance or inspection. At that time the electrical system was not entirely satisfactory, which is true of most systems that do not have proper supervision. The original system was rated at 220 volts, two-phase, sixty cycles. Considerable difficulty was experienced in starting the motors after the noon hour, due to the fact that no systematic method of starting was in effect and as soon as the whistle blew the operators would attempt to start all motors at once, with the result that all of the circuit breakers would open. To avoid this difficulty all circuit breakers were "blocked," leaving many of the motors without electrical protection.

The fuses and cutouts were located in various parts of the plant, some

CLEANING A MOTOR which has its windings caked with oil and dust is an everyday maintenance job in many plants. In a metal-stamping works there are many other problems equal in importance and these are dealt with in this article. By following a simple system of maintenance procedure the Bossert Corporation at Utica, N. Y., has experienced no serious shutdown in nine years. The details are applicable in other plants and will help in bringing about similar results.

on ceilings, some on posts, but only a few in the cabinets where they belonged. Whenever a fuse burned out it was very difficult to locate the cutout, and often it required half an hour to make a replacement. As various types of fuses were in use the particular type to fit the cutout had to be found. The company did not possess indicating meters; so tests were never made. Owing to the small amount of copper used in conductors the electrical loss was considerable and none of the motors ever received rated voltage. In some cases the drop in voltage between the transformers and the motors was over 30 per cent. Since this first system was in operation many changes have taken place and at the present time the company has one of the best installations in the country and has organized a very efficient electrical department.

Table I—Starting Torque of Squirrel-Cage Motors

The starting torque with rated voltage applied at the instant of starting from rest should not be less than the following values. Where the voltage is lower, the torque will be reduced as the square of the voltage. This table is one of the standards formulated by the Electric Power Club.

Synchronous Speed		No. Poles	Per Cent of Full-load Torque
25 Cycles	60 Cycles		
1500	3600	2	150
750	1800	4	150
500	1200	6	135
375	900	8	125
300	720	10	120
250	600	12	115
214	514	14	110

Present Electrical System Has Many Good Features

At the present time the company has in use 140 motors rated from 1/12 hp. to 100 hp., the total connected motor load being 1,100 hp. The voltage was changed from 220 to 440 volts. The present substation, which is centrally located in the plant, contains two 600-kva. transformers for the power service. The lighting service is supplied by two 100-kva. transformers, and the electric welding load is taken care of by four 200-kva., single-phase transformers. Energy is received from the Utica Gas & Electric Company on a four-wire, three-phase system over a special line from their local substation. The maximum demand on the plant is about 575 kw. and the monthly consumption of power is in the neighborhood of 185,000 kw.-hr. The reason for the large power transformer capacity, in reference to the maximum demand, is due to the low power factor of the power load. This load is at its maximum when the welding load is at its minimum. The reverse of this is true on account of the change of the manufacturing processes. Owing to the variable load conditions of the plant the power factor runs from 60 to 70 per cent. This power factor would be much lower if it were not for the operation of a 750-kva. synchronous condenser.

All circuits are protected by circuit breakers on the substation switchboard. These protect the mains and each motor is protected locally by its own fuses which are placed in the circuit before the compensators.

Motors in Plant Are Started One at a Time

All wiring of every nature is placed in iron conduit and carefully protected. The motors are of the squirrel-cage type and no slip-ring or synchronous motors are in use. In order to avoid excessive power requirements in starting, the machine foremen start the motors one at a time, beginning about five minutes before the plant is put in operation at morning and noon.

In order to avoid electrical accidents the entire installation has

Table II—Principal Items Carried in Maintenance Stock

THIS PARTIAL LIST shows some of the main items stocked by the Bossert Corporation in its metal-stamping plant, having 140 two-phase, 440-volt motors ranging in size from 1/12 hp. to 100 hp. and aggregating 1,100 hp.

I—Motors and Motor Repair Parts

100 hp., 75 hp., 50 hp., 35 hp., 15 hp., 7½ hp., 5 hp..... 2 each
25 hp. ..... 1 each
20 hp., 10 hp..... 3 each
From 3 hp. to ½ hp.....10 total

Total number equals 31 motors aggregating 705 hp.

Bearings—For all large motors one extra set for each; for smaller motors where bearings are interchangeable, less than one set per motor.

Coils—A few are stocked.

Brushes—One set for each direct-current machine.

II—Motor Starting Devices

Compensators, ranging from 7½ hp. to 100 hp. 8

Oil switches and pushbutton starters for motors of 5 hp. and under, several are stocked.

III—Fuses

Economy refillable, 600 volt, sizes up to 100 amp.—
Number of spares.....10 each
Above 100 amp..... 5 each
Extra links, all sizes.....25 each

IV—Lamps

40-, 60- and 100-watt sizes.....5 cases each
Two cases of each of the above sizes are kept marked with the company's name.
200- and 300-watt sizes.....3 cases each
500-watt size for flood lights.....1 case

V—Wire

Rubber-covered—
No. 14 single and duplex.....2000 ft. each
Nos. 12 and 10.....1000 ft. each
Nos. 8, 6, 4, 1, 0, 00.....1000 ft. each
No. 0000 .....2000 ft.
Super-Service Cord (Rome Wire Co.)
No. 16 duplex.....1000 ft.

VI—Conduit

½ in., ¾ in., 1 in. and 1¼ in.....20 lengths each
1½ in., 2 in. and 2½ in.....10 lengths each

VII—Storage Batteries

For 20 industrial truck batteries and for smaller batteries used on railroad alarm, auto-call and crossing-signal devices, spare parts are kept, including jars, separators, plates, terminal posts, connectors, and so on.

Fig. 2—This compensator handle can be locked in the open position.

The handle is passed through the slot in the arm seen hanging from the post. A padlock is then locked on the handle through a hole drilled in it. Several departments have their own locks which cannot be opened by any other department.

been made with no exposed live parts and all lighting panels are of the safety type. This, of course, is the best precaution, as the operator cannot come in contact with live circuits.

Compensators Can Be Locked Open for Motor Repairs

In order to make it impossible to start large presses or other machinery when repairs are being made, all compensators are arranged so that they can be locked with special padlocks as shown in Fig. 2. These special locks are in the care of the electrical, millwright, and production departments. These locks are all separate, and the keys of one department cannot open the lock of another. This system avoids the danger of misunderstanding between the various workmen in the three departments.

The headquarters for the electrical department are near the center of the plant, and only a short distance from the substation mentioned above. A room 70 ft. x 50 ft. is devoted entirely to this department. The room contains a few machine tools, shown in Fig. 3. It is also used for charging the storage batteries of the industrial trucks, as shown in Fig. 6. The panels directly in back of the batteries are used for charging purposes. A rope tackle, shown at the right, is used for handling these batteries. The room is well ventilated, so that the acid fumes are not noticeable. In the background of the picture can be seen two 20-kw. motor-generator sets, which are used to supply 220-volt direct-current service to the traveling cranes and electro-magnets in the receiving and storage shed. Four small motor-generator sets are used for charging storage batteries and are located in this same room.

In addition to this equipment there are two 2,400-amp. motor-generator sets located in the electroplating department. A 2-kw., 110-volt direct-current motor-generator set is also used in the tool room for operating the magnetic chucks. A similar 3-kw. set is used in operating the tabulating machine in the cost department. A dozen single-phase motors of 1 hp. to 3 hp. rating are used in various parts of the plant for different purposes.

In addition to the power and welding service the electrical department also has charge of the fire-alarm and auto-call systems used in the plant.

How the Maintenance Department Is Organized

The electrical department has been for nine years and still is in charge of H. R. Hall, who has seven men to assist him in his work. An organization chart is shown in Fig. 4. The duties of these men are as follows: Mr. Hall acts as superintendent and takes charge of all installation, maintenance, inspection, and repair work. One assistant is kept in the shop at all times for miscellaneous repairs and battery charging. Two men devote their entire time to the maintenance and inspection of the electric welding equipment, which is a very essential part of the business. The other four men devote their time to making the necessary repairs around the plant, inspections, and whatever new installation work is required. Other duties which come under the electrical department are repairs on the portable electric tools, call systems, and so forth, which are used throughout the plant. All of the necessary supplies are kept in the electrical department and are given out when proper requisitions are received.

This company does not employ an elaborate system for maintenance work, but has a common-sense plan of taking care of all equipment, and this plan produces results.

The regular routine consists of going over all motors and motor-generator sets at least once every two weeks. This consists of cleaning the motors, renewing the oil in the bearings, testing the air gaps and making a general inspection.

Fig. 3—Repairs are made in this room.

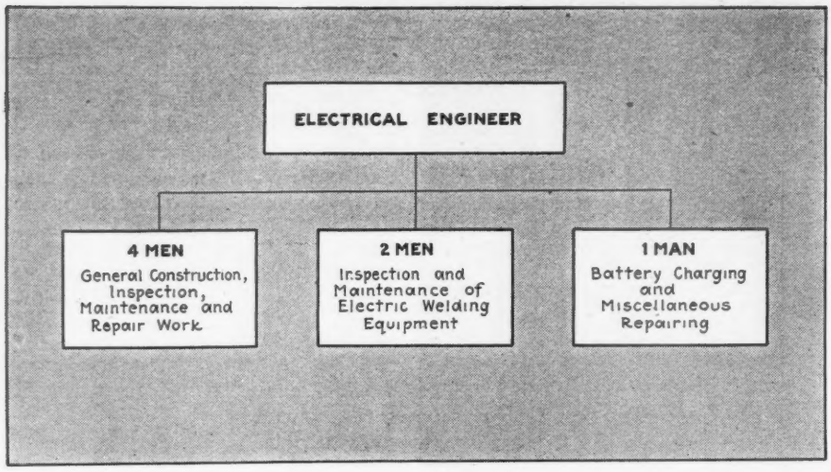


Fig. 4—Maintenance organization for metal-stamping plant having 1,100 hp. in motors.
These men take care of all electrical equipment, including motors, of which there are 140 ranging from 1/12 hp. to 100 hp., welding machines, eight industrial trucks, signal systems, lights, and other equipment.

The old oil that comes out of the motors is used in the plant for other purposes than lubrication, so that none is wasted. All bearings are thoroughly washed with kerosene before putting in the new oil. The motors are blown out at this time with compressed air at 45 lb. pressure, taken from the regular air system of the plant.

Cleaning Windings Covered with Oil and Iron Oxide

Owing to the large amount of oil vapor and iron oxide in some of the rooms, due to the operation of the presses, it is necessary to use gasoline in the form of a spray for cleaning the motors.

The suction of the motor draws in the dirty air and the oil and dirt settle on the coils. As the coils are warm the oil sets in a thin film. It is impossible in many places to secure fresh air from the outside in order to avoid this trouble. Numerous methods have been tried for removing the film but the gasoline spray has been found to be the most satisfactory. The rotor and end bells are removed from the motor and the stator is allowed to cool. Then by means of a nozzle and 30-lb. air pressure the gasoline is sprayed on the coils. This blows off the thin film of oil and dirt. Sufficient time is then allowed for the remaining gasoline to evaporate, after which the coils and the rotor are painted with quick-drying japan.

The lighting system, alarms and other electrical equipment receive regular inspections varying from once in two weeks to monthly. Eight industrial trucks are in use and these, including the batteries, are given careful inspection once a week, and are thoroughly overhauled yearly.

Graphic load charts are frequently taken, especially when any changes are made in the power requirements of a particular motor. Continuous voltage charts are taken on the main bus. All charts are filed away for future reference.

Records are kept in the substation showing the power factor, maximum demand, primary current and kilowatt-hours consumed. Electrical energy for each department is measured by a recording watt-hour meter for the use of the cost department. All substation charts are kept on file by the central station.

When trouble is experienced anywhere in the plant it is immediately reported to the electrical department, which in turn gets right after the difficulty and makes the necessary repairs. In case of a burnout or any serious difficulty which would make it necessary to remove a motor, the foreman of the department notifies not only the electrical superintendent, but also the "rigger" and "millwright" in order that no time will be lost in making the change. The employees of the electrical department are available at any time and can be reached on short notice by telephone or by the auto-call system.

Repaired Motors Are Given Brake and Ground Tests

In order to save time when one of the large motors breaks down, three of these are kept mounted on small trucks ready for taking immediately to the job in case of a breakdown. Two 100-hp. and one 75-hp. motor are always kept mounted on these

Fig. 5—Motor-record card and repair-material sheet.
On the repair material sheet are charged the repair parts and materials used on the motor. Each sheet represents one repair job. A copy of the sheet is filed with the motor record card while another copy goes to the accounting department.

FORM NO. 359 3-23-200

ELECTRIC MOTOR RECORD

DATE 19

HORSE POWER 75	TYPE OF MOTOR I-9-10-75-720	MOTOR No. 21
MANUFACTURER General Electric Co.		MANUFACTURER'S No. 1051704
USED IN DEPARTMENT Press AT Div #5		TO DRIVE MACH. No 86

R. P. M. OF SHAFTS		SIZE OF SHAFTS		PULLEY DIMENSIONS			BELTS		
MOTOR	DRIVEN	MOTOR DIA. X LONG	DRIVEN DIA. X LONG	MOTOR DIA. X WIDTH	DRIVEN DIA. X WIDTH		LENGTH	WIDTH	PLY
720	252	3 3/16"	3"	14"	15" 40"	15" MOTOR	46'	14	3
						DRIVEN	34'	14	3

G.E. Compensator #1587625 CR1034 Relay Panel #189783
From #3P1 Type 1792 Fuse Block - 150 Amp.

DATE	ORDER NO.	EMP NO.	HOURS	OPERATION
2/10/23	65	87	1½	Repairing

Form 259 2-23 5M

INDIRECT MATERIAL USED Date 2/10 1923

Quantity	DESCRIPTION	Price	Amount
8	Part Pa. G.E. Cat #129566		
4	" Qa " " " #129568		
1	" Oa " " " #129565		
5	Gal. Compensator Oil		

(Over)

For what Purpose Used Repairing Compensator — Charge to — Order No. #65 — Dept. No. Div. #5 — Acct. No. #61

Deliver to Dept. No. #61 — Man No. 87 — Credit — Store Room No. — Acct. No.

Signed H.R. Hall

trucks. One of these is shown in Fig. 1.

After the windings of a motor have been repaired it is given a ground test and a brake test. For the ground test 600-volt direct current is used. One side of the 600-volt line is connected to the winding and a 600-volt voltmeter is connected to the frame and the other side of the line. If the meter shows over 4 volts, the winding is grounded. If the ground is slight it may be removed by drying out. If the reading is very low then the 150-volt scale of the meter is used. A reading of over 15 volts on this scale indicates that the motor should be dried out. The 600-volt winding of this meter has about 60,000 ohms resistance, while that of the 150-volt winding has 15,000 ohms resistance.

If the motor winding is not grounded then a brake test is made. The brake consists of a steel friction block lined with brake lining and kept cool by water. The torque is measured at the same time that ammeter readings are taken of the motor current.

The torque is measured by means of a lever arm fastened to the friction block. The outer end of the arm rests on a spring scale. The horsepower is calculated from the formula: Hp.=(weight in lb.)×(length of arm in ft.)×(r.p.m.)÷5252.

If the current drawn is greater than the full-load current when the motor is delivering its rated horsepower, the motor is not in good condition. The trouble may be improper connections, loose rotor bars, poor bearings, lack of lubrication, and the like. After new bearings are put in a motor it is allowed to run idle until the bearings are cut in.

Compensators which have been repaired are given a ground test similar to the one described for motors. They are then tested for starting torque and current. A motor of the proper size is connected to the compensator and the brake is applied to the motor. This test is made on various taps of the compensator to determine which should be used for the service. The proper starting torques of various motors as specified by the Electric Power Club are shown in Table I. This table shows the torque when rated voltage is applied. When a lower voltage is applied from a compensator the torque is reduced as the square of the voltage. For instance, if the 70 per cent tap is used the torque will be 0.70×0.70=0.49, or 49 per cent of that shown in Table I. The current should not be over about 250 or 300 per cent of full-load current.

A record book which is kept in the office of the department contains information covering all repairs made, dates of inspection and other records and acts as a ready reference for obtaining data for the department. The results of all the work of the department are recorded in this book under their proper headings. This book becomes an important factor in the operation of the department and contains information of much value. The superintendent is able to look up any data covering inspections or trouble with the electrical equipment, and experience has taught the department the necessity of writing out in detail its activities.

Each motor has a record card like that shown in Fig. 5. This card contains data on the location of the motor, and also information on the compensator, pulley, bearings, and the like. In Fig. 5 is also shown the material sheet used when making repairs. On this sheet are put down the materials to be used on a repair job. The original sheet then serves as a requisition on the stock room. One copy of the sheet is filed with the motor record card. After the stock room has issued the material the sheet is sent to the accounting division. *(Continued on page 324)*

Table III—Portable Meters Used in a Large Metal-Stamping Plant

Alternating-Current Meters	Direct-Current Meters
1 Two-phase graphic wattmeter	1 Graphic wattmeter
1 Graphic ammeter	1 Graphic ammeter
1 Two-phase indicating wattmeter	1 50-amp. ammeter
1 150-amp. ammeter*	1 500-amp. ammeter
1 300-amp. ammeter*	1 300-volt voltmeter
1 30-volt voltmeter	1 750-volt voltmeter
1 120-volt voltmeter	
1 300-volt voltmeter**	

*A cable-testing current-transformer set accompanies these meters.

**A multiplier is used with this meter to measure voltages of 600 volts, 900 volts and 1800 volts.

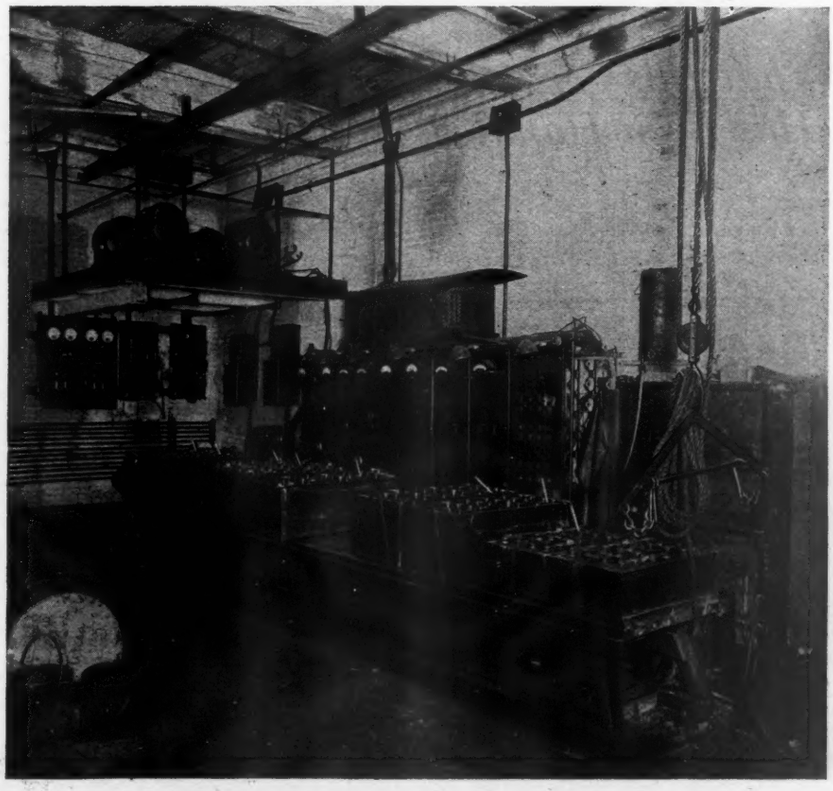


Fig. 6—Where the batteries are charged.

This is another side of the room shown in Fig. 3. Note the stands made for holding the batteries and the runway overhead for moving the batteries after they are lifted by the rope tackle.

The inspector makes out a report like this covering all apparatus inspected. This is known as report form No. 1 and is filed in a loose leaf binder for use in making up report form No. 2 shown on page 292. This sheet measures 6 in. by 9.5 in.

How to Figure Rates for

Industrial Maintenance Service

With an Outline of What this Service Includes and How it Has Been Handled

By G. W. BARTHOLMEW

Manager, Industrial Electric Service of Erie, Erie, Pa.

IN THE April issue of INDUSTRIAL ENGINEER, page 211, the writer answered an inquiry regarding a plan for contracting to render a maintenance service to industrial plants on a monthly basis. Owing to the inquiries which have since been received from readers of INDUSTRIAL ENGINEER regarding further details of figuring out rates for this service the writer has compiled a description of the method which he has developed in conducting such a maintenance service during the past two years.

Briefly, the fees are based on the work called for by an individual motor and vary with the size, type, accessibility and character of control used. An aggregate of all motor fees constitute the monthly fee. Discounts are arranged for installations of over ten motors with additional charges for installations of less than ten motors. A base rate has been worked up to take care of a semi-monthly service with additions for a weekly service and deductions for monthly periods with a minimum rate for small installations.

IN THIS ARTICLE Mr. Bartholmew outlines details of a maintenance service for small industrial plants. These details are based upon two years of experience in developing this work and embody plans which have resulted in savings to customers and a fair profit for the service rendered. Such a service is badly needed in many cities and electrical repair shops can handle it without much additional expenditure.

The popularity of this service may be judged from the fact that the only cancellations of the service agreements made have been due to retrenchment on the part of industrial plants.

In large industrial plants an electrical maintenance force is a necessity and economy when sufficient equipment is operated to keep this force busy. In the smaller plants, however, where maintenance and repair work is not sufficient to keep one or two experienced maintenance men busy all the time and they are put on odd jobs in their spare time, then the maintenance force is un-economical when a repair service can be contracted for by an outside organization. This is due to the fact that when maintenance men are not busy all the time they will take considerably more than the necessary time in

completing maintenance jobs. Moreover, the odd jobs which are assigned to them to do could be performed by a less expensive man in a satisfactory manner.

Previous to the time the writer established his maintenance service while working as an estimator on power construction, he observed that in many cases when an outside repairman was called in on a repair job that he attended only to the defects that he was called upon to handle. He left untouched defects in other equipment which, if properly cared for at the time, would have prevented shut-downs and consequent expensive repairs. It was evident to him then that if it were possible for small industrial plants to employ the services of a competent repair man on a part-time basis many troubles could be anticipated before they became serious and a material saving in operation and production made possible. He then set about to devise a method for doing this work that would prove mutually remunerative to himself as well as his customers through the savings that would result.

The first question faced in organizing this service was the matter of rates. At the start an arbitrary schedule of rates was developed. This was based on my experience as an electrical repair man in several large industries in the central west covering a period of several years. During the past two years since this service has been in operation more definite schedules have been developed and are shown in Tables I, II, III, and IV. The service which is provided has been divided into four classes which are described as plans Nos. 1, 2, 3 and 4 in the form of service agreement which is now used, as shown on this page.

Plan No. 1 provides for a thorough inspection at regular intervals and the rendering of a written report giving details of the results of this inspection together with recommendations for changes or repairs and adjustments necessary to insure safe and economical operation.

Plan No. 2 includes plan No. 1 together with a written report on same and in addition oiling, wiping and repairs of a minor nature, such as brush seating, correcting brush tension and surface defects in the commutator, sanding rough commu-

This Service Agreement Outlines the Work to Be Done Under Plans Nos. 1, 2, 3 and 4.

INDUSTRIAL ELECTRIC SERVICE OF ERIE

SERVICE AGREEMENT

We the INDUSTRIAL ELECTRIC SERVICE OF ERIE agree to furnish services of Plans Nos. _____ as outlined in description of plans as shown in this agreement, on electrical equipment consisting of _____ motors and starting equipment of same, located at _____ property of _____ for the sum of _____ per _____ payable _____

Plan No. 1, thorough inspection of listed equipment at intervals of _____, furnishing written report of same and recommending any changes necessary to safe and economical operation of same.

Plan No. 2 includes Plan No. 1 and minor repairs and adjustments not covered in Plan No. 4 at intervals of _____

Plan No. 3. Oiling services at intervals of _____

Plan No. 4 for replacements of parts, repairs to parts where necessary to partially or completely dismantle, rewiring partially or completely, or to make new installations, a rate of _____ per man per hour for the first five (5) hours and a rate of _____ per man per hour for each hour over five (5) hours, will be furnished;men to competent electrical workers.

Trouble calls to the amount of _____ hours will be allowed between inspections without charge. The maximum number of trouble calls without charge allowable under this agreement shall not exceed _____per _____. All additional trouble calls will be charged at the rate of _____per hour, per man.

Owner to furnish any necessary materials.

Date _____ Signed _____

Expires _____ INDUSTRIAL ELECTRIC SERVICE OF ERIE

By _____

This group of freezers in an ice cream factory shows ideal conditions for thorough inspection.

An Example Showing How the Schedule of Rates Is Applied to a 27-Motor Job

Motor No.	Size	Motor Rate	Total	Starter Rate	Total	Whole Rate
7	Fract.	$0.55	$3.85	$0.00	$0.00	$ 3.85
8	1 to 3	.65	5.20	.06	.48	5.68
5	3 to 5	.80	4.00	.08	.40	4.40
6	5	1.00	6.00	.10	.60	6.60
1	7½	1.15	1.15	.11	.11	1.26
					Total	$21.79

tators, tightening loose connections in leads and many other small defects that take but a short time to correct.

Plan No. 3 covers an oiling service only, of all electrical equipment at frequent intervals. No repairs are covered in this plan.

Plan No. 4—Where extensive repairs are required and construction work needed it is agreed to furnish a competent man on a sliding rate of charge determined by the length of time necessary to complete the work. To regular customers it has been found advisable to discontinue the sliding rate and charge for the work on a flat-rate basis, owing to the fact that I employ only competent and experienced men. Another point that interests our regular customers is that I call on them for help when they are in a position to furnish it.

To encourage the contracting of maintenance service on a regular and continuous basis, all construction and repair work for other than regular customers is billed out at a rate 20 per cent in excess of the labor rates furnished with a maintenance contract. The time allowed for trouble calls is 10 per cent of the rate of 75 cents per hour for the period between regular inspections. All time over the allowable time for regular inspections is billed as an extra charge.

For example, a rate of $6.00 per period (period is the interval between inspections) is assumed. Trouble calls to the amount of 60 cents, which is usually figured as one hour if the charge is less than $1.00, are allowed. All time over one hour is charged for at regular rates, say $1.50 per hour. Then if two and a half hours are consumed in making a repair, we charge one and a half hours, or $2.25 in addition to our rate for the period which makes a total of $8.25 for the period.

Although it is not stipulated in the service agreement, it has been our custom when the trouble is the result of neglect on the part of the inspector to do the work without a charge. If this were written into the service agreement there would be a tendency to abuse this clause. The following instance will illustrate this: In one case a switch was reported defective because the blade cross-bar was warped. The operator of the machine in shutting it down pulled the switch sufficient to break the contact on one phase only with the result that one phase of the motor was roasted. In this instance it was only necessary to refer to the report which called this defect to the attention of the customer and advised the repair of the switch. In this particular plant a contractor was doing the repair work and we were making inspections and reports only. This particular repair was made in due time but not until another motor had roasted out in a similar way. It is quite evident that a decided saving could have been affected if this customer had contracted in the beginning for our plan covering repair work as well as inspection. This was later brought about.

In order to explain how our schedule of rates is applied in contracting for this service, we will describe the charges for a particular customer, who happens to be a confectioner using 27 motors. These are d. c. motors and vary in size from fractional horsepower to 7½ hp. Upon gaining his interest in our service plans we obtained a list of the motors in service. When this was done we arranged them in horsepower classes according to the schedule outlined in plan No. 2, Table No. III. It will be noted at the bottom of the schedule that when starting equipment is used there is an addition to the motor fee of 10 per cent. The tabulation for this particular customer is shown above.

In this classification the total rate of $21.79 will be termed the whole rate. This whole rate is based on two inspections per month. It will be noted that a table of additions and deductions are a part of plan No. 2 in Tables II and III. These are applied in working out the final rate.

Considerable moisture in washing down is present in this installation of pasteurizers in an ice cream factory—a condition which demands inspection.

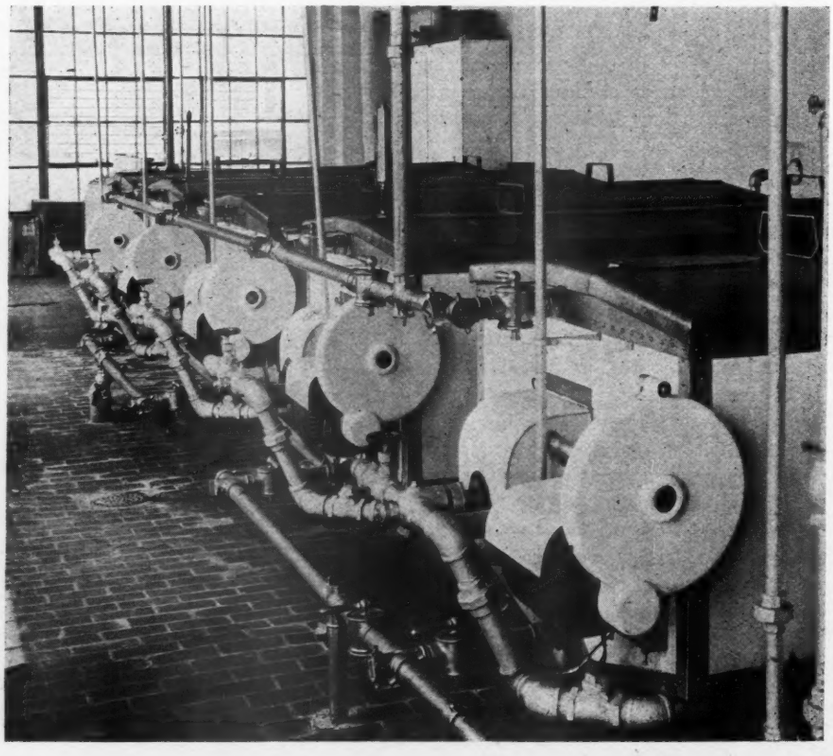
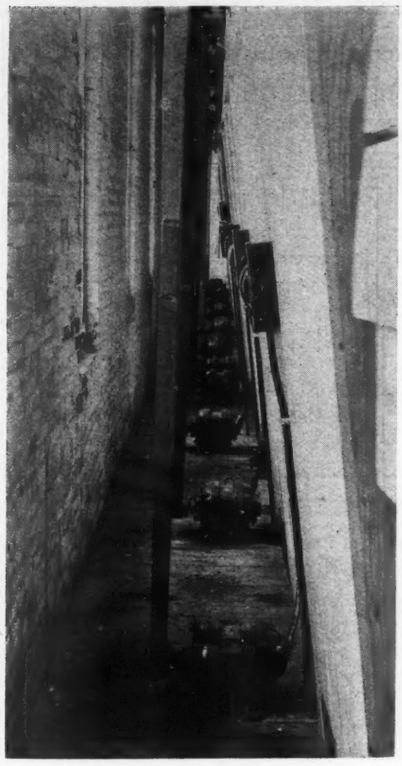


Table I—Plan No. 1 Includes Inspections Only and Report

This plan is based upon two inspections per month and the report gives recommendations for changes necessary to safe and economical operation. The minimum rate is $10.00 per year.

Number of Motors	Rate per Motor per Month
5 to 10	$0.70
10 to 15	.65
15 to 20	.60
20 to 25	.55
25 to 30	.50
30 to 40	.45
40 to 50	.40



This installation is of special interest because the motors operate 24 hours a day and there is no one in attendance from 6:30 p. m. to 7:00 a. m. The photograph shows 11 dryers in a macaroni factory. The apparent slanting of the walls is due to camera-distortion.

Table IV—Plan No. 3 Calls for an Oiling Service Only

Oiling is done twice a week. The minimum rate is $15.00 per year with the following schedule for groups of motors:

Number of Motors	Rate per Motor per Month
1 to 5	$0.80
5 to 10	.70
10 to 15	.65
15 to 20	.60
20 to 25	.55
25 to 30	.50
30 to 40	.45
40 to 50	.40
Over 50	Special rates

There are 27 motors in this installation which makes it fall in a class between 25 and 35 motors, calling for a reduction of 10 per cent from the whole rate. Thus $21.79 less $2.18 gives $19.61 as the base rate charged.

In determining the frequency of service required there are several points to consider; namely, (1) age of equipment, (2) care in handling it, (3) surroundings, (4) amount of usage.

In the case of this particular customer we found the equipment of comparatively recent make, operations in manipulation of equipment carefully handled, that there was little moisture close to the equipment and an average of 25 per cent usage was safe. We recommended a monthly service; this was considered sufficient, in view of the conditions.

Since all rates in the tables accompanying this article are based on a semi-monthly service it is necessary to arrive at a rate that is just to the customer and to the service contractor for a monthly service. It is reasonable to expect and it is an absolute fact that a greater number of defects will result in thirty days than in fifteen days; therefore, it would be inconsistent to cut the rate in half.

Let us assume that we can place this inspection on the same dates with one of equal size and located somewhere near it. In this particular case this was actually done and we allowed a 5 per cent reduction from the base rate. Since operators are careful in handling equipment a further reduction of 10 per cent was allowed. Also since there was practically no moisture but some dust surrounding the equipment, a reduction of 5 per cent was made. For usage on the basis mentioned above a further reduction of 10 per cent was allowed, making a total reduction from the base rate of 30 per cent.

Since the base rate was figured as $19.61 the 30 per cent reduction gives the rate of charge for the service as $13.73 on the monthly service plan No. 2 outlined in Table No. III. But in this, as in all cases, the rates are made even so that in this particular instance the billed rate for the service was $13.00.

Tables II and III—Plan No. 2 Which Provides for More Service Than Plan No. 1

In addition to the work covered in Plan No. 1, this service plan includes oiling, wiping, adjustments and minor repairs that require little time.

TABLE NO. II—A. C. EQUIPMENT

Horsepower	Rate
Fractional	$0.55
1 to 3	0.65
3 to 5	0.80
5	1.00
7½	1.15
10	1.30
15	1.45
20	1.55
25	1.65
30	1.75
40	1.85
50	1.95
75	2.20
100	2.50
125	2.80

TABLE NO. III—D. C. EQUIPMENT

Horsepower	Rate
Fractional	$0.70
1 to 3	0.80
3 to 5	0.95
5	1.05
7½	1.15
10	1.25
15	1.35
20	1.45
25	1.55
30	1.65
40	1.75
50	1.85
75	1.95
100	2.10
125	2.25

Rates are based on semi-monthly service.

For compensator, add	15 per cent	1 to 5 motors, add	15 per cent
For slip-ring equipment,	25 per cent	5 to 10 motors, add	10 per cent
For starter D. C.,	10 per cent	10 to 15 motors, add	5 per cent
		15 to 25 motors, deduct	5 per cent
		25 to 35 motors, deduct	10 per cent
		Over 35, special rates.	
		Minimum rate, $3.50 per month.	

Table V—Information Compiled for Equipment Serviced

EQUIPMENT INSPECTED FOR RICHARD ROE & SON.

No.	Application	Maker	Serial	Frame Type	H.P.	R.P.M.	Volts	Phase	Cycles	Amps. per Terminal
1	Paper cutter	G. E.	1234235	K. T.	5	1800	220	3	60	13.
2	Saw trimmer	Holtzer-Cabot	334974	H.R. 1	¼	1750	110	1	60	5.
3	Cylinder Press No. 1	Allis-Chalmers	86441	A. N.	5	1800	220	3	60	14.

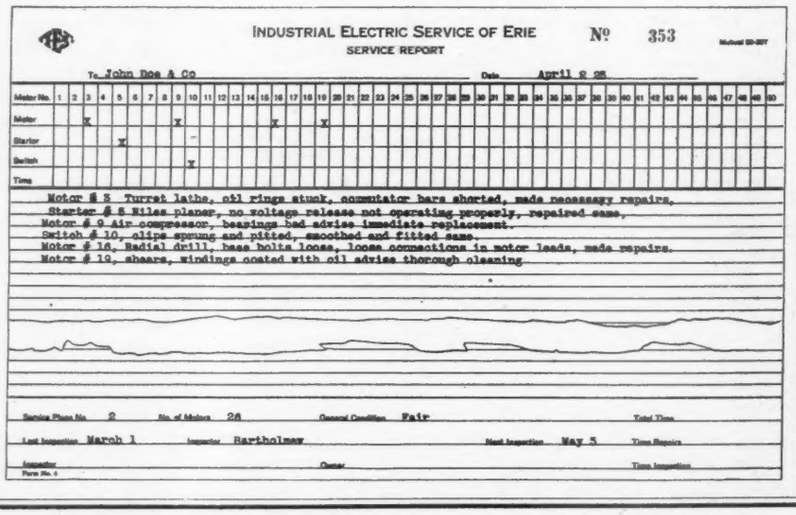
Table VI—Form Used to Indicate Time Consumed and Cost of Inspections and Repairs

This table is made up for a 12-motor job and weekly service. A time rate of 75 cents per hour is used with an overhead charge of 20 per cent.

Date of Inspection	3/15	3/22	3/30	4/7	4/13	4/21	4/28
Cost at 75c per hour	$1.50	$1.12	$1.87	$1.12	$0.37	$1.87	$0.37
Add overhead at 20 per cent	.30	.22	.37	.22	.07	.36	.07
Total cost	$1.80	$1.34	$2.24	$1.34	$0.44	$2.23	$0.44
Price of inspection	$2.81	$2.81	$2.81	$2.81	$2.81	$2.81	$2.81
Cost of inspection	1.80	1.34	2.24	1.34	.44	2.23	.44
Profit	$1.01	$1.47	$0.57	$1.47	$2.37	$0.58	$2.37

Report Form No. 2—Reports to customers are made up in this form.

This monthly report is made up from the inspection reports shown on page 288. The original goes to the customer and a duplicate is kept on file.



INDUSTRIAL ELECTRIC SERVICE OF ERIE Nº 353
SERVICE REPORT

To John Doe & Co Date April 2 28

Motor Nº 5 Turret lathe, oil rings stuck, commutator bars shorted, made necessary repairs.
Starter # 5 Niles planer, no voltage release not operating properly, repaired same.
Motor # 9 Air compressor, bearings bad advise immediate replacement.
Switch # 10, clips sprung and pitted, smoothed and fitted same.
Motor # 16, Radial drill, base bolts loose, loose connections in motor leads, made repairs.
Motor # 19, shears, windings coated with oil advise thorough cleaning.

Service Plans No. 2 No. of Motors 26 General Condition Fair Total Time
Last Inspection March 1 Inspector Bartholmew Next Inspection May 5 Time Repairs
Inspector Owner Time Inspection

We will assume now that the customer has accepted this rate and has made a contract for the service. The next step is to make up a detailed list of equipment included in the service. Such a list is shown in Table No. V. Each motor is numbered progressively through the plant and inspection routes are laid out in such a way as to eliminate retracing steps. This motor number is used to identify motors on all reports, records and correspondence.

This list often proves of value in saving trips to plants to get information in ordering repair parts and in case of oversight in taking nameplate data. It serves also as a check on additions to equipment that are made. A copy of this list is furnished to the customer and gives him a detailed list of his motor equipment which is something rarely found in the average size of plant.

When several plants are contracting for this service it is advisable to check up rates and correct any deficiency. Four plants were selected for this purpose as follows: A confectioner, a foundry, a printing establishment and an amusement park. A form was developed from data on time consumed in making inspections and repairs at frequent intervals and a tabulation worked up such as shown in Table No. VI. This particular table refers to a twelve-motor job which uses a weekly service.

It will be noted that from the first four inspections there was a very small profit; however, it will also be noted that on other inspections tabulated the profit was considerably larger, due to the inspector becoming familiar with the plant layout and the characteristics of the machines.

Table No. VI is based on an hourly rate of 75 cents and an overhead charge of 20 per cent. The writer believes the charges are reasonable when all things are taken into consideration. When making up this table it is necessary while on the job to note carefully the total time and the time on repairs. The difference represents the time devoted to inspection. By referring to the first column of Table No. VI, it will be noted that on March 15 the total time spent was two hours. The time taken by repairs was one hour and 24 minutes and the time by inspection 36 minutes. Four weeks later, April 13, the total time taken was 30 minutes with no repairs and 30 minutes for inspection. The profit in the first case was $1.01 and in the second, $2.39.

Cost averages may also be computed from Table No. VI and time averages per motor. These figures should be checked from time to time to indicate an increasing or falling off of profits.

No materials are included in the charge for our service. Such material as needed is furnished by us and billed in addition to the service charge.

On regular inspection trips the inspector carries individual motor report blanks such as the form shown as No. 1. *(Continued on page 324)*

Practical Details and Tables for

Laying Out Unequal Groupings of Coils

In Induction Motors Having from Twenty to Twenty-Four Poles, Two and Three-Phase

THIS ARTICLE IS the fourth of a series by A. C. Roe on connecting induction motors. The other articles have appeared in the past three issues of INDUSTRIAL ENGINEER. They have dealt with the grouping of coils and the various connections required to give series and parallel windings. The present article shows tables and diagrams for twenty to twenty-four poles. It also describes a scheme for determining where the larger groups are placed in a winding which has unequal groups.

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric and Manufacturing Company

IN THE MAY issue, pages 241 to 250, details were given for the laying out of unequal groupings of coils with special reference to securing a balance in the winding. In what follows the subject is continued from that issue with details given for induction motors of twenty to twenty-four poles, two and three phase.

"From the three-phase table for 4 to 48 poles, inclusive, and from 3 slots per pole up to 150 slots, the number of unequally grouped windings is about six times the number of equally grouped windings, which will be a considerable advantage to the designer. The different numbers of poles that may be wound with a given number of slots by using the unequal plus the equal groupings is considerably increased over the different numbers of poles that may be wound with equal groupings only. With four poles, for each possible winding in equal groups there are three windings in unequal groups. With eight poles there are seven unequal group windings for each equal group winding, and with ten poles the number of unequal group windings is nine times the number of equal group windings, and so on."

Table I—Example Showing How to Locate Coils in Unequal Groups

For such diagrams use section paper.
Three-phase; 20 poles; 144 slots; 60 phase groups.
Least common multiple for 144 slots and 60 phase groups is 720.
Slot interval, 5 spaces. Phase groups, 12 spaces. Pole groups, 36 spaces.

Pole No.	Phase A.	Phase B.	Phase C.
1	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .	. 0 . . . . 0 0
2	. . . 0 . . . 0 . . .	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .
3	. . 0 . . . 0	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .
4	. 0 . . . 0 0	0 . . . 0 . . . 0 . . .	. . 0 . . . 0 . . . . .
5	0 . . . 0 . . . . 0 .	. . . 0 . . . 0	. 0 . . . 0 . . . . .
6	0 . . . 0 . . . 0 . .	. . 0 . . . 0 0	. 0 . . . 0 . . . . 0 .
7	. . . 0 . . . 0 . . .	. 0 . . . 0 . . . 0 . .	0 . . . 0 . . . 0 . . .
8	. . 0 . . . 0	0 . . . 0 . . . 0 . . .	. . . 0 . . . 0 . . . .
9	. 0 . . . 0 0	. . . 0 . . . 0	. . 0 . . . 0 . . . . .
10	0 . . . 0 . . . . 0 .	. . 0 . . . 0 0	. 0 . . . 0 . . . . .
11	0 . . . 0 . . . 0 . .	. . . 0 . . . 0	. 0 . . . 0 . . . . 0 .
12	. . . 0 . . . 0 . . .	. . 0 . . . 0	0 . . . 0 . . . . 0 . .
13	. . 0 . . . 0	. 0 . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .
14	. 0 . . . 0 0	0 . . . 0 . . . 0 . . .	. . 0 . . . . 0 . . . .
15	0 . . . 0 . . . . 0 .	. . . 0 . . . 0	. 0 . . . 0 . . . . .
16	0 . . . 0 . . . 0 . .	. . 0 . . . 0 0	. 0 . . . 0 . . . . 0 .
17	. . . 0 . . . 0 . . .	. 0 . . . 0 . . . 0 . .	0 . . . 0 . . . 0 . . .
18	. . 0 . . . 0	0 . . . 0 . . . 0 . . .	. . . 0 . . . 0 . . . .
19	. 0 . . . 0 0	. . . 0 . . . 0	. . 0 . . . 0 . . . . .
20	0 . . . 0 . . . . 0 .	. . 0 . . . 0 0	. 0 . . . 0 . . . . .

Number of coils in each phase group.

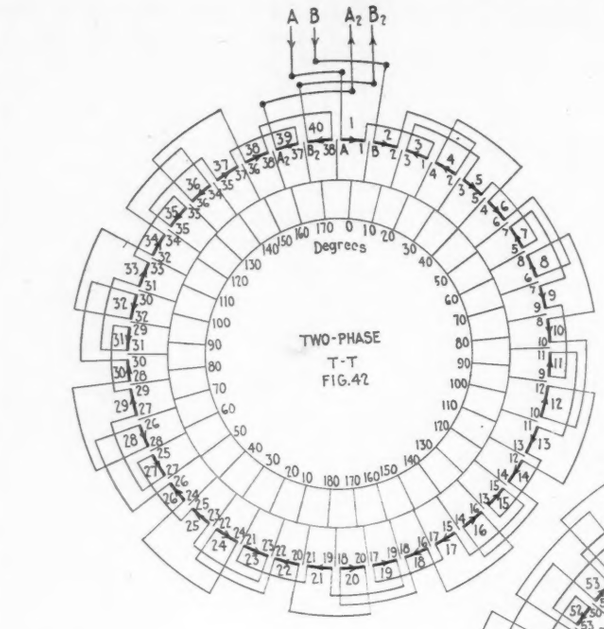
Pole No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Phase A	3	2	2	2	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2	3
Phase B	2	2	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2	3	3	2
Phase C	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2

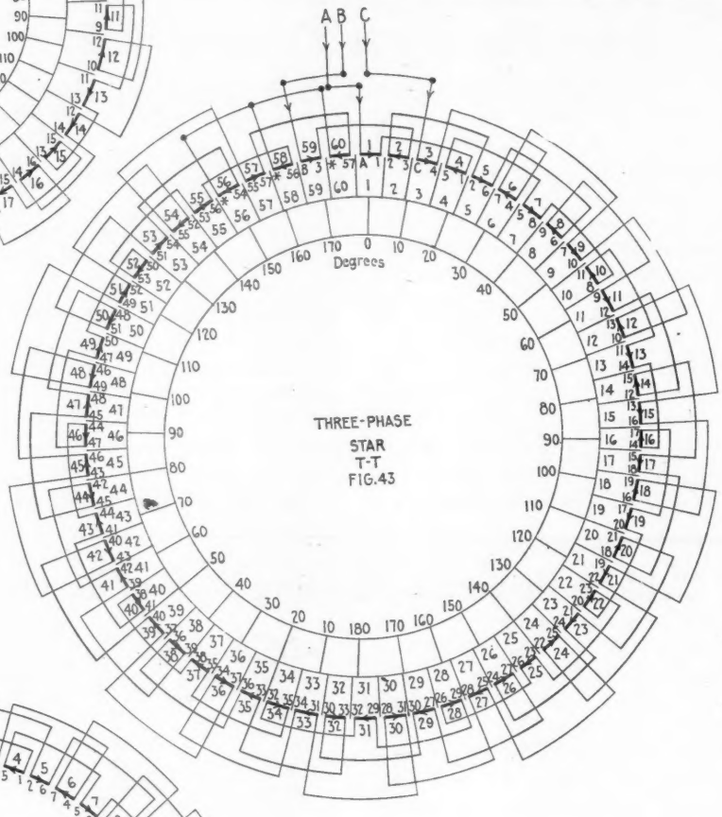
One side of each coil is represented in the diagram by 0. The other side of the coils is to be allowed for by the pitch factor. Coils under alternate poles must be reverse-connected.

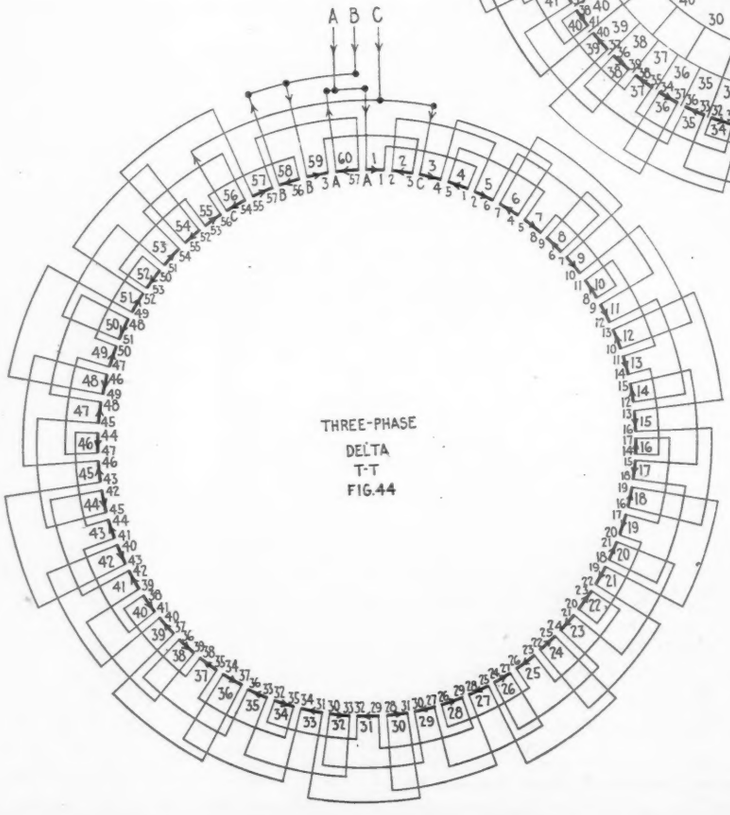
The above diagram shows that this winding may be connected in two or four multiple circuits, as the diagram forms four similar series for each phase. This winding may also be connected for two phases in which case the phase groups would be 18 spaces.

Twenty-Pole Windings

See Tables on Pages 295 and 296 Showing the Corresponding Groupings and Method of Connecting Ends of Groups.







Twenty-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE, TOP-TO-TOP, CHART T

Coils	Group Numbers																				No. Large Groups	No. Small Groups
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38	39 40		
48	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	8	32
54	2[k] 2	1 1	1 1	2 2	1 1	2 1	1 1	2 2	1 1	1 1	2 2[k]	1 1	1 1	2 2	1 1	1 2	1 1	2 2	1 1	1 1	14	26
60	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	20	20
62	2 2	1 1	2 2	2–1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 2–1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	22	18
72	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	32	8
84	3 2	2 2	2 2	2 2	2 2	2 3	2 2	2 2	2 2	2 2	3 2	2 2	2 2	2 2	2 2	2 3	2 2	2 2	2 2	2 2	4	36
86	3 2	2 2	2 2	3–1 2	2 2	2 3	2 2	2 2	2 2	2 2	3 2	2 2	2 2	2 3–1	2 2	2 3	2 2	2 2	2 2	2 2	6	34
90	3[k] 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3[k]	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 3	2 2	2 2	10	30
96	3 3	3 3	2 2	2 2	2 2	3 3	3 3	2 2	2 2	2 2	3 3	3 3	2 2	2 2	2 2	3 3	3 3	2 2	2 2	2 2	16	24
104	2 2	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3	24	16
108	2 2	3 3	3 2	3 3	3 3	2 2	3 3	2 3	3 3	3 3	2 2	3 3	3 2	3 3	3 3	2 2	3 3	2 3	3 3	3 3	28	12
128	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	3 3	3 3		
135	4[k] 4	3 3	4–1 3	4 4	3 3	4 3	3 3	4 4	3 3	3 3	4 4[k]	3 3	3 3	4 4	3 3	3 4	3 3	4 4	3 3	3 3	15	25
144	3 3	3 3	4 4	4 4	4 4	3 3	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	4 4	3 3	3 3	4 4	4 4	4 4		
150	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4[k]	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4[k] 4	4 4	30	10
156	3 4	4 4	4 4	4 4	4 4	4 3	4 4	4 4	4 4	4 4	3 4	4 4	4 4	4 4	4 4	4 3	4 4	4 4	4 4	4 4	36	4
168	5 5	4 4	4 4	4 4	4 4	5 5	4 4	4 4	4 4	4 4	5 5	4 4	4 4	4 4	4 4	5 5	4 4	4 4	4 4	4 4		
180	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4		
216	6 6	6 6	5 5	5 5	5 5	6 6	6 6	5 5	5 5	5 5	6 6	6 6	5 5	5 5	5 5	6 6	6 6	5 5	5 5	5 5		

[k]A coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding.

THREE-PHASE, TOP-TO-TOP, CHART J

Coils	Group Numbers																																														No. Large Groups	No. Small Groups
	1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48	49 50 51	52 53 54	55 56 57	58 59 60		
62	1 1 1	1 2–1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	2–1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1		
72	2 1 1	1 1 2	1 1 1	1 2 1	1 1 1	2 1 1	1 1 2	1 1 1	1 2 1	1 1 1	2 1 1	1 1 2	1 1 1	1 2 1	1 1 1	2 1 1	1 1 2	1 1 1	1 2 1	1 1 1	12	48
80	2 1 2	1 2 1	1 1 1	1 2 1	2 1 2	1 1 1	1 1 2	1 2 1	2 1 1	2–1 1 1	2 1 2	1 2 1	1 2–1 1	1 2 1	2 1 2	1 1 1	1 1 2	1 2 1	2 1 1	1 1 1	20	40
84	2 2 2	1 1 1	2 2 2	1 1 1	1 1 1	2 2 2	1 1 1	2 2 2	1 1 1	1 1 1	2 2 2	1 1 1	2 2 2	1 1 1	1 1 1	2 2 2	1 1 1	2 2 2	1 1 1	1 1 1	24	36
86	2 2 2	1 1 1	2 2 2	1 1 2–1	1 1 1	2 2 2	1 1 1	2 2 2	1 1 1	1 1 1	2 2 2	1 2–1 1	2 2 2	1 1 1	1 1 1	2 2 2	1 1 1	2 2 2	1 1 1	1 1 1	26	34
90	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	30	30
96	1 1 1	2 2 2	1 1 1	2 2 2	2 2 2	1 1 1	2 2 2	1 1 1	2 2 2	2 2 2	1 1 1	2 2 2	1 1 1	2 2 2	2 2 2	1 1 1	2 2 2	1 1 1	2 2 2	2 2 2	36	24
104	2–1 2 1	2 1 2	2 2 2	2 1 2	1 2 1	2 2 2	2 2 1	2 1 2	2–1 2 2	2 2 2	1 2 1	2 1 2	2 2 2	2 1 2	1 2 1	2 2 2	2 2 1	2 1 2	1 2 2	2 2 2	44	16
108	1 2 2	2 2 1	2 2 2	2 1 2	2 2 2	1 2 2	2 2 1	2 2 2	2 1 2	2 2 2	1 2 2	2 2 1	2 2 2	2 1 2	2 2 2	1 2 2	2 2 1	2 2 2	2 1 2	2 2 2	48	12
128	3 2 2	2 2 2	2 2 2	2 3 2	2 2 2	2 3–1 2	2 2 3	2 2 2	2 2 2	2 2 2	3 2 2	2 2 2	2 2 2	2 3 2	2 2 3–1	2 2 2	2 2 3	2 3 2	2 2 3	2 2 2	8	52
135	3 2 2	2 3 2	2 2 3	2 2 2	3 2 2	2 3 2	2 2 3	2 2 2	3 2 2	2 3 2	2 2 3	2 2 3	3 2 2	2 3 2	2 2 3	2 2 3	3 2 2	2 3 2	2 2 3	2 2 2	15	45
144	3 3 3	2 2 2	3 3 3	2 2 2	2 2 2	3 3 3	2 2 2	3 3 3	2 2 2	2 2 2	3 3 3	2 2 2	3 3 3	2 2 2	2 2 2	3 3 3	2 2 2	3 3 3	2 2 2	2 2 2		
150	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2		
156	2 2 2	3 3 3	2 2 2	3 3 3	3 3 3	2 2 2	3 3 3	2 2 2	3 3 3	3 3 3	2 2 2	3 3 3	2 2 2	3 3 3	2 2 2	3 3 3	2 2 2	3 3 3	2 2 2	3 3 3		
160	2 2 2	3 3 3	2 2 2	3 3 3	3 3 3	2 2 3–1	3 3 3	2 2 2	3 3 3	3 3 3	3–1 2 2	3 3 3	2 3–1 2	3 3 3	3 3 3	2 2 3–1	3 3 3	2 2 2	3 3 3	3 3 3	40	20
168	2 3 3	3 3 2	3 3 3	3 2 3	3 3 3	2 3 3	3 3 2	3 3 3	3 2 3	3 3 3	2 3 3	3 3 2	3 3 3	3 2 3	4 4 4	4 4 4	4 4 4	3 3 3	4 4 4	4 4 4		
216	3 3 3	4 4 4	3 3 3	4 4 4	4 4 4	3 3 3	4 4 4	3 3 3	4 4 4	4 4 4	3 3 3	4 4 4	3 3 3	4. 4 4	4 4 4	3 3 3	4 4 4	3 3 3	4 4. 4	4 4 4		

Twenty-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two-Phase, Top-to-Top. See Fig. 42

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17
2 Parallel									A_2	B_2	A	B							A_2
4 Parallel																			
5 Parallel							A_2	B_2	A 9	B 10	9	10							
10 Parallel			A_2	B_2	A	B			A_2	B_2	A_2	B_2	A	B	A_2	B_2	A	B	19
20 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A_2
																			A

Three-Phase Star, Top-to Top. See Fig. 43

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30
2 Parallel																										*		*	B
4 Parallel											*		*	B	*	A		C											
5 Parallel									*		B 12	*	A 14	12	C 16	14	B	*	16	A	*	C	*	B	*	A	27	C	29	27
10 Parallel		*		*	B	*	A	*		C	*	A	*	B	*	A	B	*	C	*	B	*	A	*	C	*	B	*	A	B
20 Parallel	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	

Three-Phase Delta, Top-to-Top. See Fig. 44

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30
2 Parallel																										C		B	B
4 Parallel											C		B	B	A	A		C											
5 Parallel									C		B	B 12	A	A 14	C	12	C 16	B	14	B	A	16	A	C	B	B	A	A	27	C	29	27
10 Parallel		C		B	B	A	A			C	B	A	C	C	B	A	B	A	C	A	C	B	B	A	C	C	B	B	A	C	B	B
20 Parallel	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C			

Twenty-Two-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two-Phase, Top-to-Top. See Fig. 45

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17	20 18
2 Parallel																				
11 Parallel			A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2
22 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B

Three-Phase Star, Top-to-Top. See Fig. 46

GroupNo.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	33 30
2Parallel																													*		*	B
11Parallel		*		*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	30	*	A 32	* 30
22Parallel	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B

Three-Phase Delta, Top-to-top. See Fig. 47

GroupNo.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Series	A 1	2 63	C 3	4 1	2 5	6 3	4 7	8 5	6 9	10 7	8 11	12 9	10 13	14 11	12 15	16 13	14 17	18 15	16 19	20 17	18 21	22 19	20 23	24 21	22 25	26 23	24 27	28 25	26 29	30 27	28 31	32 29
2Parallel																													C		B	B
11Parallel		C		B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B 29	A	A 31	C 29
22Parallel	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B

tion Motor Windings

——Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*)

Two-Phase (Continued)

20	21	22	23	24	25	-26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
20 18 B_2	19 21 A	20 2: B	23 21	24 22	23 25	24 26	27 25	28 26	27 29 A:	28 30 B_2	31 29 A	32 30 B	31 33	32 34	35 33	36 34	35 37	36 38	A_2 37	B_2 38
20 B: B	19 A A_2	20 B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	29 A A_2	30 B B_2	A_2 29 A	B_2 30 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A	B

Three-Phase Star (Continued)

30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
31 28 *	29 32 A	33 30	31 34 C	35 32	33 36	37 34	35 38	39 36	37 40	41 38	39 42 *	43 40	41 44 *	45 42 B	43 46 *	47 44 A	45 48	49 46 C	47 50	51 48	49 52	53 50	51 54	55 52	53 56	* 54	55 57	* 56	B 3	* 57
31 * C	29 A *	* B	31 C *	* A	B *	* C	A *	* B	C *	* A	B 42 * C	* A	A 44 * B	* 42 B	C 46 * A	* 44 A	B *	46 C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	* C

Three-Phase Delta (Continued)

30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
31 28 A	29 32 A	33 30	31 34 C	35 32	33 36	37 34	35 38	39 36	37 40	41 38	39 42 C	43 40	41 44 B	45 42 B	43 46 A	47 44 A	45 48	49 46 C	47 50	51 48	49 52	53 50	51 54	55 52	53 56	C 54	55 57	B 56	B 3	A 57
31 A C	29 A B	C B	31 C A	B A	B A	A C	A C	C B	C B	B A	B 42 C A	A C	A 44 B B	C 42 B	C 46 A A	B 44 A	B C	A 46 C	A C	C B	B A	B A	A C	A C	B B	C B	A A	C	C

tion Motor Windings

——— Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*)

Two-Phase, Top-to-Top (Continued)

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
19 21 A A_2	20 22 B B_2	23 21 A_2 A	24 22 B_2 B	23 25 A A_2	24 26 B B_2	27 25 A_2 A	28 26 B_2 B	27 29 A A_2	28 30 B B_2	31 29 A_2 A	32 30 B_2 B	31 33 A A_2	32 34 B B_2	35 33 A_2 A	36 34 B_2 B	35 37 A A_2	36 38 B B_2	39 37 A_2 A	40 38 B_2 B	39 41 A A_2	40 42 B B_2	A_2 41 A	B_2 42 B
A 21 A_2	B 22 B_2	A_2 21 A	B_2 22 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A	B

Three-Phase Star (Continued)

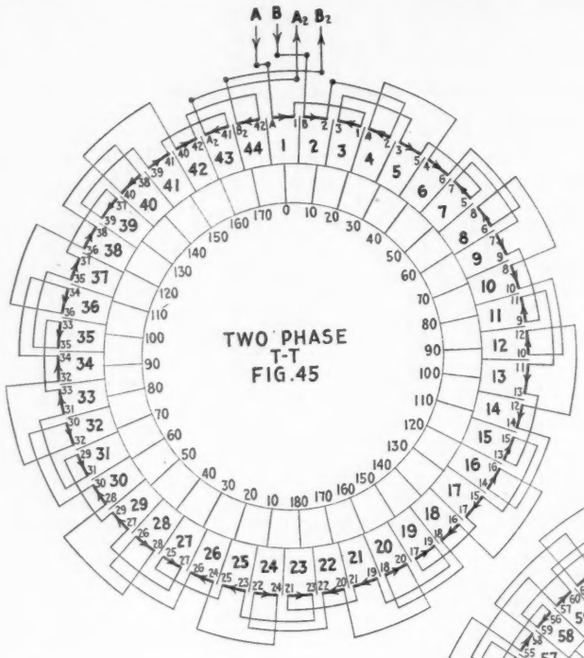
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
31 34 *	35 32 A	33 36	37 34 C	35 38	39 36	37 40	41 38	39 42	43 40	41 44	45 42	43 46	47 44	45 48	49 46	47 50	51 48	49 52	53 50	51 54	55 52	53 56	57 54	55 58	59 56	57 60	61 58	59 62	* 60	61 63	* 62	B 3	* 63
C 34 *	* 32 A	B *	* 34 C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	* C

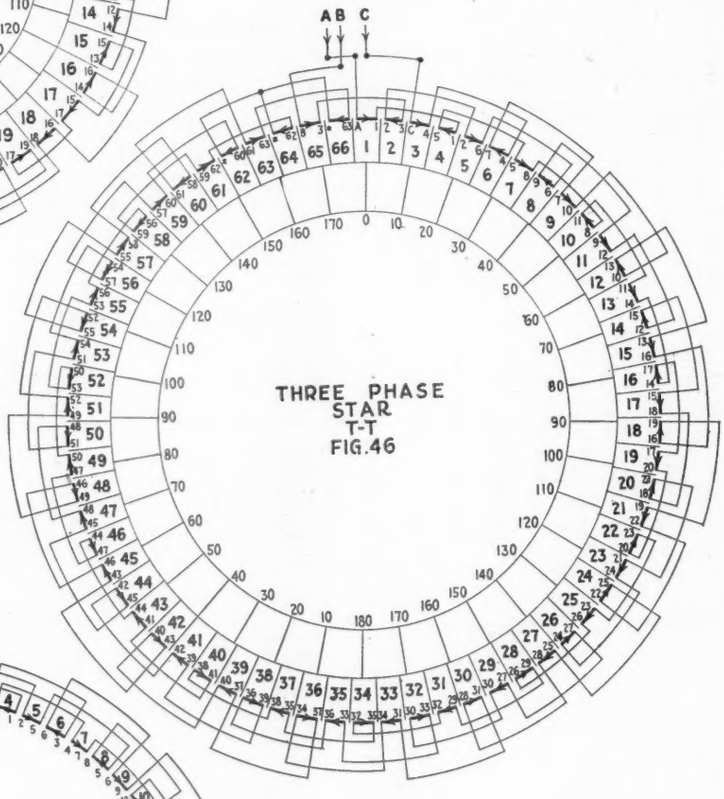
Three Phase Delta (Continued)

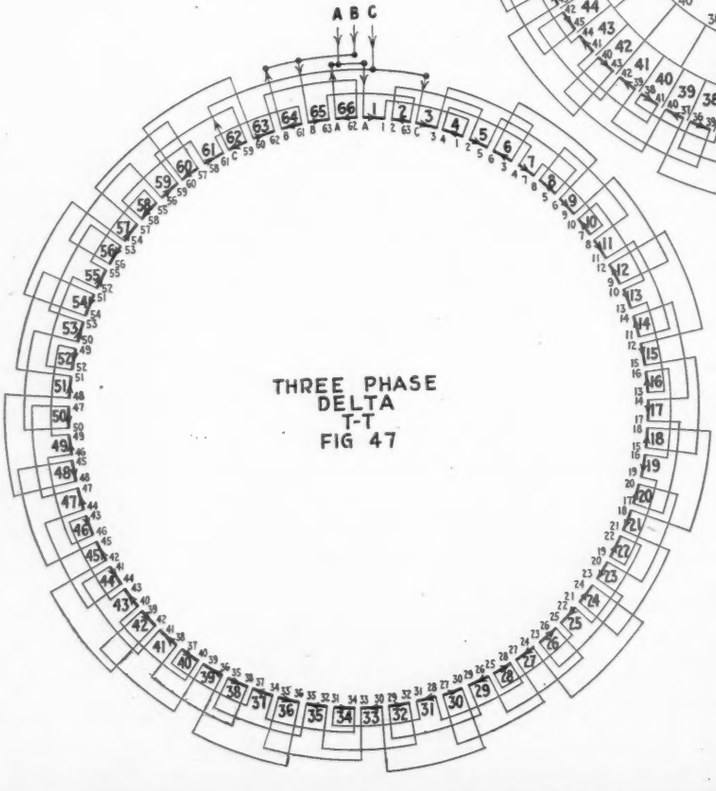
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
30 33 A	34 31 A	32 35	36 33 C	34 37	38 35	36 39	40 37	38 41	42 39	40 43	44 41	42 45	46 43	44 47	48 45	46 49	50 47	48 51	52 49	50 53	54 51	52 55	56 53	54 57	58 55	56 59	60 57	58 61	C 59	60 62	B 61	B 63	A 62
C 33 A	B 32 A	B C	A 33 C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	C B	B A	C B	A A	C C	B B	A C	C B	C B	B A	B A	A C	A B	B B	C A	A A	C C	C

Twenty-Two-Pole Windings

See Tables on Pages 299 and 296 Showing the Corresponding Groupings and Methods of Connecting Ends of Groups.







Twenty-Two-Pole Windings—Unequal Coil Grouping

TWO-PHASE, TOP-TO-TOP. CHART V

No. Coils	Group Numbers. 1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38	39 40	41 42	43 44	No. Large Groups	No. Small Groups
54	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	2k 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 2k	1 1	1 1	10	34
60	2 2	1 1	1 2	2 1	1 1	2 2	1 1	1 1	2 2	1 1	1 1	2 2	1 1	1 2	2 1	1 1	2 2	1 1	1 1	2 2	1 1	1 1	16	28
62	2 2	1 1	1 2	2 1	1 1	2 2	1 1	2–1 1	2 2	1 1	1 1	2 2	1 2–1	1 2	2 1	1 1	2 2	1 1	1 1	2 2	1 1	1 1	18	26
72	1 1	2 2	2 1	1 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 1	1 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	28	16
80	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	2 2	36	8
84	1 2	2 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2	2 2	2 2	1 2	2 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2	2 2	2 2	40	4
86	1 2k	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2k 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	42	2
90	3k 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 3k	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2	42
96	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	8	36
104	3 3	2 2	2 3	3 2	2 2	3 3	2 2	2 2	3 3	2 2	2 2	3 3	2 2	2 3	3 2	2 2	3 3	2 2	2 2	3 3	2 2	2 2		
108	3 3	3 3	2 2	2 2	3 3	3 3	3 3	2 2	2 3	3 2	2 2	3 3	3 3	2 2	2 2	2 2	3 3	2 2	3 3	2 2	2 2	2 2	20	24
120	2 2	3 3	3 3	3 3	3 3	2 2	3 3	3 3	2 2	3 3	3 3	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	2 2	3 3	3 3	32	12
128	2 3	3 3	3 3	3 3	3 3	3 2	3 3	3 3	3 3	3 3	3 3	2 3	3 3	3 3	3 3	3 3	3 2	3 3	3 3	3 3	3 3	3 3		
135	4k 3	3 3	3 3	3 3	3 3	3 3	4–1 3	3 3	3 3	3 3	3 3	3 4k	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3	41
144	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	12	32
150	4 4	3 3	3 4	4 3	3 3	4 4	3 3	4–1 3	4 4	3 3	3 3	4 4	3 4–1	3 4	4 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3		
156	3 3	3 3	4 4	4 4	4 4	3 3	3 3	4 4	4 3	3 4	4 4	3 3	3 3	4 4	4 4	4 4	3 3	4 4	4 3	3 3	3 3	3 3	24	20
160	3 3	4 4	4 3	3 4	4 4	3 3	4 4	4 4	3 3	4 4	4 4	3 3	4 4	4 3	3 4	4 4	3 3	4 4	4 4	3 3	4 4	4 4		
168	3 3	4 4	4 4	4 4	4 4	3 3	4 4	4 4	4 4	4 4	4 4	3 3	4 4	4 4	4 4	4 4	3 3	4 4	4 4	4 4	4 4	4 4		
180	5k 4	4 4	4 4	4 4	4 4	4 5k	4 4	4 4	4 4	4 4	4 4	5k 4	4 4	4 4	4 4	4 4	4 5k	4 4	4 4	4 4	4 4	4 4	4	40
216	4 5	5 5	5 5	5 5	5 5	5 4	5 5	5 5	5 5	5 5	5 5	4 5	5 5	5 5	5 5	5 5	5 4	5 5	5 5	5 5	5 5	5 5		
240	6 6	6 6	5 5	5 5	5 5	6 6	6 6	5 5	5 6	6 5	5 5	6 6	6 6	5 5	6 5	6 6	6 5	6 6	5 5	5 6	6 5	5 5		

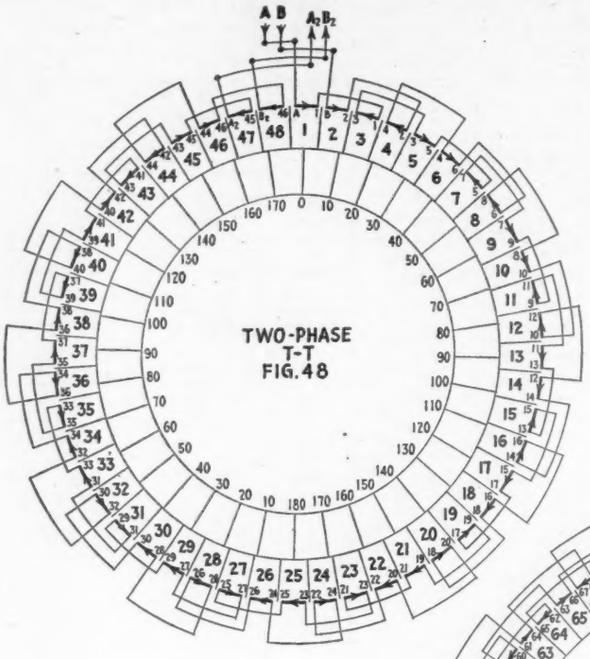
THREE-PHASE, TOP-TO-TOP, CHART U

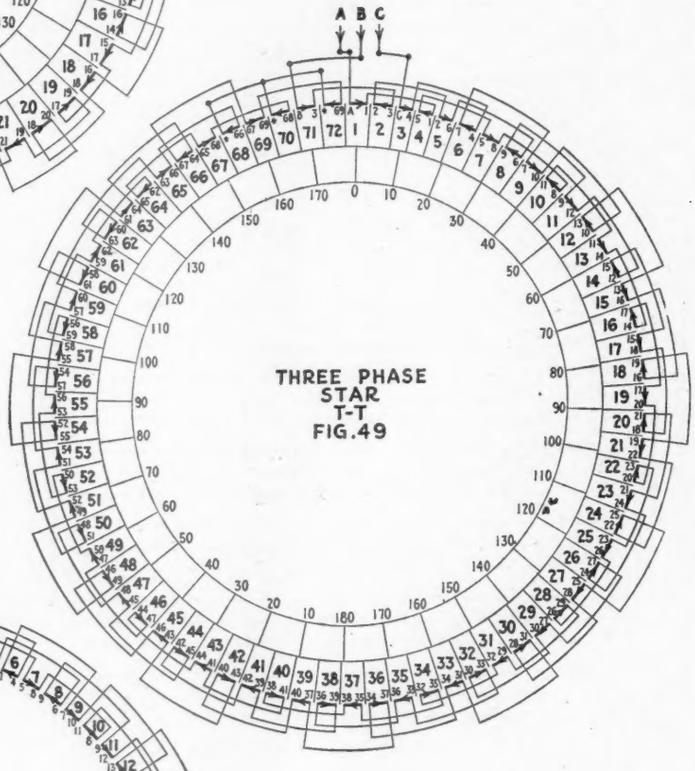
No. Coils	Group Numbers 1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48	49 50 51	52 53 54	55 56 57	58 59 60	61 62 63	64 65 66	No. Large Groups	No. Small Groups
72	2 1 1	1 1 1	1 1 1	1 1 2	1 1 1	1 1 1	1 1 1	1 2 1	1 1 1	1 1 1	1 1 1	2 1 1	1 1 1	1 1 1	1 1 2	1 1 1	1 1 1	1 1 1	1 2 1	1 1 1	1 1 1	1 1 1	6	60
80	2 1 1	1 1 2	1 1 1	1 2 1	1 2–1 1	1 1 2	1 1 1	1 2 1	1 1 1	2 1 1	1 1 1	2 1 1	1 1 2	1 2–1 1	1 2 1	1 1 1	1 1 2	1 1 1	1 2 1	1 1 1	2 1 1	1 1 1	14	52
84	2 1 2	1 2 1	2 1 2	1 2 1	1 1 1	1 1 2	1 1 2	1 2 1	2 1 1	1 1 1	1 1 1	2 1 2	1 2 1	2 1 2	1 2 1	1 1 1	1 1 1	1 1 2	1 2 1	2 1 1	1 1 1	1 1 1	18	48
86	2 1 2	1 2 1	2 1 2	1 2 1	1 1 1	1 2–1 1	1 1 2	1 2 1	2 1 1	1 1 1	1 1 1	2 1 2	1 2 1	2 1 2	1 2 1	1 1 2–1	1 1 1	1 1 2	1 2 1	2 1 1	1 1 1	1 1 1		
90	2 1 2	1 2 1	2 1 2	1 2 1	1 1 1	2 1 2	1 2 1	2 1 2	1 2 1	1 1 1	1 1 1	2 1 2	1 2 1	1 2 1	1 2 1	1 1 1	1 1 1	1 2 1	2 1 2	1 2 1	1 1 1	1 1 1	20	46
96	2 1 2	1 2 1	2 1 2	1 2 1	1 1 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	1 1 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	24	42
104	1 2 1	2 1 2	1 2 1	2 1 2	2 2 2	1 2 1	2 2–1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 2–1	2 1 2	1 2 1	2 1 2	2 2 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	30	36
108	1 2 1	2 1 2	1 2 1	2 1 2	2 2 2	1 2 1	2 1 2	1 2 1	2 1 2	2 2 2	2 2 2	1 2 1	2 1 2	1 2 1	2 1 2	2 2 2	1 2 1	2 1 2	1 2 1	2 1 2	2 2 2	2 2 2	38	28
120	1 2 2	2 2 1	2 2 2	2 1 2	2 2 2	2 2 1	2 2 2	2 1 2	2 2 2	1 2 2	2 2 1	1 2 2	2 2 1	2 2 2	2 1 2	2 2 2	2 2 1	2 2 2	2 1 2	2 2 2	1 2 2	2 2 2	42	24
128	1 2 2	2 2 2	2 2 2	2 2 2–1	2 2 2	2 2 2	2 2 2	2 1 2	2 2 2	2 2 2	2 2 2	1 2 2	2 2 2	2 2 2	2 2 1	2 2 2	2 2 2	2 2 2	2 2–1 2	2 2 2	2 2 2	2 2 2	54	12
135	3k 2 2	2 2 2	2 2 2	2 2 2	2 2 2	2 2 2	2 2 2	2 3k 2	2 2 2	2 2 2	2 2 2	2 2 2	2 2 2	2 2 2	2 2 3k	2 2 2	2 2 2	2 2 2	2 2 2	2 2 2	2 2 2	2 2 2	62	4
144	3 2 2	2 2 3	2 2 2	2 3 2	2 2 2	2 2 3	2 2 2	2 3 2	2 2 2	3 2 2	2 2 2	3 2 2	2 2 3	2 2 2	2 3 2	2 2 2	2 2 3	2 2 2	2 3 2	2 2 2	3 2 2	3 2 2	3	63
150	3 2 3	2 3 2	3 2 3	2 3 2	2 2 2	2 2 2	2 2 3	2 3 2	3 2 2	2 2 2	2 2 2	3 2 3	2 3 2	3 2 3	2 3 2	2 2 2	2 2 2	2 2 3	2 3 2	3 2 2	2 2 2	2 2 2	12	54
156	3 2 3	2 3 2	3 2 3	2 2 2	3 2 3	2 2 2	2 3 2	3 2 3	2 3 2	2 2 2	2 2 2	3 2 3	2 3 2	3 2 3	2 3 2	2 2 2	3 2 3	2 3 2	3 2 3	2 3 2	2 2 2	2 2 2		
160	3 2 3	2 3 2	3 2 3	2 3 2	3–1 2 3–1	3 2 3	2 3 2	3 2 3	2 3 2	2 2 2	2 2 2	3 2 3	2 3 2	3 2 3	2 3 2	2 2 2	3 2 3	2 3 2	3 2 3	2 3 2	2 3–1 2	2 3–1 2		
168	2 3 2	3 2 3	2 3 2	3 2 3	3 3 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	3 3 3	2 3 2	3 2 3	2 3 2	3 2 3	2 3 2	3 2 3	28	38
180	2 3 2	3 2 3	2 3 2	3 2 3	3 3 3	3 3 3	3 3 2	3 2 3	2 3 3	3 3 3	3 3 3	2 3 2	3 2 3	2 3 2	3 2 3	3 3 3	3 3 3	3 3 2	3 2 3	2 3 3	3 3 3	3 3 3	36	30
216	4 3 4	3 4 3	4 3 4	3 4 3	3 3 3	3 3 3	3 3 4	3 4 3	4 3 3	3 3 3	3 3 3	4 3 4	3 4 3	4 3 4	3 4 3	3 3 3	3 3 3	3 4 3	3 4 3	4 3 3	3 3 3	3 3 3	48	18
240	3 4 3	4 3 4	3 4 3	4 3 4	4 4 4	3 4 3	4 3 4	3 4 3	4 3 4	4 4 4	4 4 4	3 4 3	4 3 4	3 4 3	4 3 4	4 4 4	3 4 3	4 3 4	3 4 3	4 3 4	4 4 4	4 4 4		

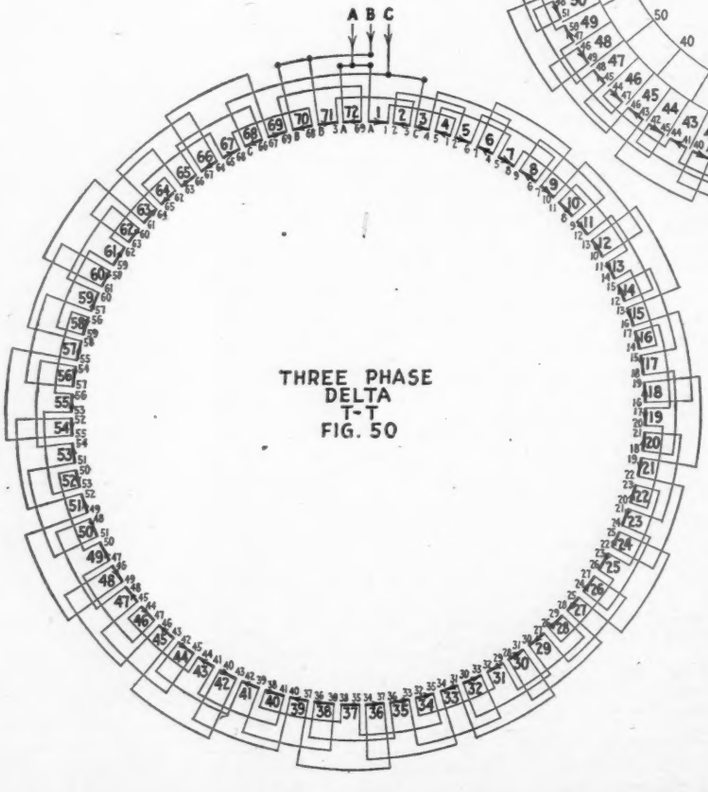
kA coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding.

Twenty-Four-Pole Windings

See Tables on Pages 301 and 302 Showing the Corresponding Groupings and Methods of Connecting Ends of Groups.







Twenty-Four-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE. TOP-TO-TOP. CHART W

No. Coils	Group Numbers																																				No. Large Groups	No. Small Groups
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38	39 40	41 42	43 44	45 46	47 48														
54	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1													6	42
60	2 2	1 1	1 1	1 1	2^k 2^k	1 1	1 1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 1	1 1	2^k 2^k	1 1	1 1	1 1	2 2	1 1	1 1	1 1													12	36
62	2 2	1 1	2–1 1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 2–1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 1	1 1													14	34
72	2 2	1 1	2 2	1 1	2 2	1 L	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1													24	24
80	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	1 1	2 2													32	16
84	1 1	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	2 2	1 1	2 2													36	12
86	1 1	2 2	2 2	2 2	1 2–1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2													38	10
90	1 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2–1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2													42	6
104	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2													8	40
108	3 3	2 2	2 2	2 2	3^k 3^k	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2														
120	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3^k 3^k	2 2	2 2	2 2	3 3	2 2	2 2	2 2														
128	2 2	3 3	3 3	2 2	3 3	3 3	2 2	3 3	3 3	2 2	3 3	3 3	2 2	3 3	3 3	2 2	3 3	2 2	3 3	3 3	2 2	3 3	2 2	3 3														
135	2 2	3 3	3 3	3 3	2 2	3 3	3 3	3 3	3 3	3 3	2 2	3 3	3 3	3 3	2 3–1	3 3	3 3	3 3	3 3	3 3	2 2	3 3	3 3	3 3													9	39
150	4^k 4^k	3 3	3 3	3 3	3 3	3 3	3 3	3 3	4^k 4^k	3 3	3 3	3 3	3 3	3 3	3 3	3 3	4^k 4^k	3 3	3 3	3 3	3 3	3 3	3 3	3 3														
156	4 4	3 3	3 3	4^k 4^k	3 3	3 3	3 3	3 3	4 4	3 3	3 3	3 3	4 4	3 3	3 3	3 3	4^k 4^k	3 3	3 3	3 3	4 4	3 3	3 3	3 3														
160	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3													16	32
168	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3														
180	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4														
216	5 5	4 4	5 5	4 4	5 5	4 4	4 4	4 4	5 5	4 4	5 5	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4														

[k]A coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding.

UNEQUAL COIL GROUPING

THREE-PHASE, TOP-TO-TOP CHART O

| No. Coils | Group Numbers | | | | | | | | | | | | | | | | | | |

An even greater number of windings, about twice as many, is possible if the windings already mentioned are included. These are the windings which are practically satisfactory, although not absolutely balanced according to Mr. Tingley.

Furthermore, it is possible to get still more combinations by killing coils or leaving slots empty as already outlined in the April issue of INDUSTRIAL ENGINEER.

"With 108 slots balanced three-phase windings may be made for any number of poles met with in ordinary practice, besides a number of two-phase windings. This is of great practical value in induction motor designing as standard or existing punchings may be used for special motors. In two- and three-speed induction motors, using one, two or three primary windings, it will greatly facilitate the design by allowing a greater choice in the number of slots that may be used.

"A fourteen-pole, three-phase, 126-slot, squirrel-cage induction motor may be carrying a certain load which will permit a desirable increase or decrease in speed. Usually this would require a new motor, but Table II, on page 243 of the May issue, shows that, so far as the stator slots are concerned, stator windings for eight, ten, twelve or sixteen poles could be applied. Possibly simply reconnecting the old stator windings for twelve or sixteen poles would be practicable.

"A desirable generator winding often requires a few more or less conductors than may be obtained in equal groups per phase per pole, and a small increase or decrease in the number of slots would permit the use of the winding. If in designing a twenty-pole, 120-slot, three-phase generator it is found that a winding having two conductors per slot is very desirable, but that this would give about 10 per cent too few or too many conductors, the larger number of conductors may be employed by using fractional-pitch coils and 120 slots. But there may be no way of increasing the smaller number of conductors except by making a very undesirable winding. However, by using unequal groups of coils the number of slots may be increased or decreased to any extent in steps of three, and the number of conductors thereby properly adjusted.

"Any of these three-phase windings may be connected in star or delta. They may also be connected in multiple circuits where the series of coils permit.

"With lap windings the number of coils is equal to the number of slots, but similar relations may also be applied to chain and basket windings where the number of coils is half the number of slots. Chain windings have certain advantages for high-voltage coils, but they are seldom used for three phases with an odd number of pairs of poles on account of the special or 'twisted' coils required. By using a suitable number of slots, in many cases a three-phase chain winding for an even number

Twenty-Four-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two-Phase, Top-to-Top. See Fig. 48

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17	20 18	19 21	20 22
2 Parallel																						
3 Parallel															A_2	B_2	A	B				
4 Parallel											A_2	B_2	A	B	15	16	15	16				
6 Parallel							A_2	B_2	A	B	11	12	11	12	A_2	B_2	A	B				
8 Parallel				A_2		B_2	7 A	8 B	7	8	A_2	B_2	A	B	15	16	15 A_2	16 B_2	A	B		
12 Parallel			A_2	B_2	A 5	B 6	A_2 5	B_2 6	A	B					A_2	B	A 17	B 18	A_2 17	B_2 18	A	B
24 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2

Three-Phase Star, Top-to-Top. See Fig. 49

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	33 30	31 34	35 32	33 36
2 Parallel																																			
3 Parallel																																			
4 Parallel																																			
6 Parallel																																			
8 Parallel																																			
12 Parallel																																			
24 Parallel																																			

Three-Phase Delta, Top-to-Top. See Fig. 50

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	33 30	31 34	35 32	33 36
2 Parallel																																			
3 Parallel																																			
4 Parallel																																			
6 Parallel																																			
8 Parallel																																			
12 Parallel																																			
24 Parallel																																			

of pairs of poles may be connected for an odd number of pairs of poles. As an example, a twenty-pole, 120-slot sixty-coil, three-phase chain winding may be connected for fourteen poles.

"A fractional number of slots per pole will have a tendency, in generators with accurately spaced poles, to reduce the magnetic locking and thereby the magnetic losses, especially with a small number of open slots per pole. In generators having a fractional number of open slots per pole the poles should be accurately spaced at the faces, for otherwise the voltage generated may vary with the position of the poles, especially with a small number of slots per pole, and thin-filament incandescent lamps operated from such a generator may flicker.

"In split-frame machines special attention must be given to the practicable relations of slots and punching segments to have them built properly at the split in the frame. Where segmental slot dies are used it may be difficult to adapt the required number of slots to segments of acceptable size. In some cases this may be accomplished by arranging to build the punchings spirally. With segments blanked out and with indexed slots the difficulties may not be so great, although an excessively large number of different segments may result.

"Unequally grouped windings will have a tendency to improve the wave forms by substituting a large number of small ripples for a few large ones, as produced by the equally-grouped windings. Fractional group windings, however, reduce the form factor of the wave as they give the effect of a large number of slots per pole as regards wave-form.

"Table I is a sample diagram showing how the coil groups for the poles and phases may be readily determined. It is simply a scale that is divisible a whole number of times by the number of phase groups and slots. The number of phase groups is the number of phases times the number of poles. The number of scale divisions is the least common multiple of the number of slots and phase groups. It may then be termed a Least-Common-Multiple diagram. It may be in circular form, or in tabular form as written on a typewriter, or it may be very quickly written out on section paper. Section paper is the most convenient and the tabular form preferable, with the phase groups in vertical columns, as the possibilities of multiple connections may be more easily noted by inspection. Two or more similar series of coil groups in a phase may be connected in multiple. The use of multiple circuits is often important for magnetic balancing and also for making changes in voltage."

In making the diagram on section paper the pole numbers are each put down as shown in the column at the left. Then to the right of each of these numbers is placed a scale represented by a number of dots. This number *(Continued on page 325)*

tion Motor Windings

Correct together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*)

Two-Phase (Continued)

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
23 21 A_2 23 A_2	24 22 B_2 24 B_2	23 25 A 23 A	24 26 B 24 B	27 25	28 26	27 29	28 30	31 29 A_2 31	32 30 B_2 32	31 33 A 31	32 34 B 32	35 33 A_2	36 34 B_2	35 37 A	36 38 B	39 37	40 38	39 41	40 42	43 41	44 42	43 45	44 46	A_2 45	B_2 46
A	B	A_2	B_2	A_2 A	B_2 B	A_2 A 29 A_2	B_2 B 30 B_2	A_2 31 A A_2 29 A	B_2 32 B B_2 30 B	A 31 A	B 32 B	35 A_2 A_2	36 B_2 B	35 A A_2	36 B B_2	A_2 39 A_2 A	B_2 40 B_2 B	A 39 A_2 A 41 A_2	B 40 B_2 B 42 B_2	A A_2 41 A	B B_2 42 B	A A_2	B B_2	A	B

Three-Phase Star (Continued)

36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
37 34 * 37 *	35 38 A 35 A	39 36	37 40 C 37 C	41 38	39 42	43 40	41 44	45 42 * 45	43 46	47 44 * 47	45 48 B 45	49 46 * 49	47 50 A 47	51 48 *	49 52 C 49	53 50 *	51 54 B	55 52 *	53 56 A	57 54 *	55 58 C	59 56	57 60 B	61 58 *	59 62 A	63 60	61 64 C	65 62 *	63 66 A	67 64	65 68 C	* 66	67 69	* 68	B 3	* 69	
C	*	B	*	*	B 42 *	*	A 44 *	*45 B * 42 B	C 46 *	*47 A * 44 A	45 B *	49 C * 46 C	47 A *	*	51 C 49 C	*	53 51 B	55 * *	53 A A	* 57 *	55 C B	*	59 * *	B 57 * B 60 *	* 61 *	59 * A 62 *	B 60 B	C 61 * C 64 *	A * 62 A	B	* 64 C	A *	C B	*	A	*	C

Three-Phase Delta (Continued)

36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
37 34 A 37 A	35 38 A 35 A	39 36	37 40 C 37 C	41 38	39 42	43 40	41 44	45 42 C 45	43 46	47 44 B 47	45 48 B 45	49 46 A 49	47 50 A 47	51 48 C	49 52 C 49	53 50 B	51 54 B	55 52 A	53 56 A	57 54	55 58 C	59 56	57 60 B	61 58	59 62 A	63 60	61 64 C	65 62 A	63 66 A	67 64	65 68 C	66	67 69	B 68	B 3	A 69	
C	B	C B	B	A	B A	B C	C 42 A C	A 44 B	C	B 45 C 42 B	A 47 A 46 B	45 B A 46 A	A 49 C 47 A	C	51 C 49 C	B	53 B	A	55 A	A	C 57 C	B	59 B	B 57 C B 60 A	A 61 A	59 B A 62 B	C. 60 B	B C 61 A C 64 A	B 62 A	B	C 64 A	A C	B	B	A	C	C

WHEN A LEATHER BELT becomes worn, oily or opens at the laps, industrial works usually discard them and buy new. However, these may be cleaned and cut down or rebuilt, if necessary, with a saving of at least 15 per cent or more in the annual belt bill. Some of the methods of reclaiming belts and their advantages are given in this article.

Some of the Hows and Whys of

Reclaiming Leather Belts

Methods That May Be Used to Reduce Operating and Maintenance Costs by Reusing Discarded Belts

This and several of the accompanying photographs were taken in the belt shop of the Deering Works of the International Harvester Company. Here two men reclaim, repair and install all belts as explained in this article.

By FRANK E. GOODING
Associate Editor, Industrial Engineer

ESTIMATES resulting from an investigation of scrapped leather belts in industrial plants show that about 65 per cent of the belting that is discarded has in it a period of useful life still that is worth while to reclaim. Even though it is not reclaimed, leather belts still have a scrap value of 25 cents or more per pound, depending on the leather market. Trimmings, cracked, burned, or worn-out sections and other parts not worth working up into new belting, also have a small scrap value. However, it usually pays to use up this scrap around the factory instead of selling it. For example, such scrap pieces may be used for shoe soles in foundries, for hand leathers, and many other purposes for which, in altogether too many cases, new pieces of leather belting are used. Also small scraps may be used in casehardening.

Almost any industrial plant can save 15 per cent or more of its annual leather belt bill if the men in the plant fully understand and apply the practical principles of cutting down and reclaiming this discarded leather belting. Most leather belt manufacturers will overhaul and rebuild belts. Also several concerns specialize on this type of work and have special facilities and ability based on wide experience. In one plant, for example, the belt bill has been reduced about 50 per cent. That this concern is still maintaining a saving in belt costs is shown by the fact that another plant of about the same size, which makes a similar product, has an annual belt expense of more than double. In computing this saving only the actual belt costs are used. No allowance whatever is made for the decrease in number of shutdowns and its resulting increase in production, factors which can only be estimated. Later in this article more will be given on methods that can be used to decrease belting expenses.

In every industrial works the man responsible for belt maintenance should acquire a good working knowledge of leather and how belts are made. He should also study the service requirements of different installations that require a belt rating larger than ordinarily might be expected. This experience will help him to judge what is wrong with a belt when it gives way under service conditions earlier than might be expected. It should always be an established rule, whenever a belt gives way in service, to find out why it gave way before it is replaced by another belt. When this is done any projecting edges or points which scrape or rub on the belt may be

removed, pulleys that are loose or out of line may be lined up properly, a belt that is too weak replaced by a heavier one, and other factors eliminated which interfere with the effective operation of the belt and shorten its life.

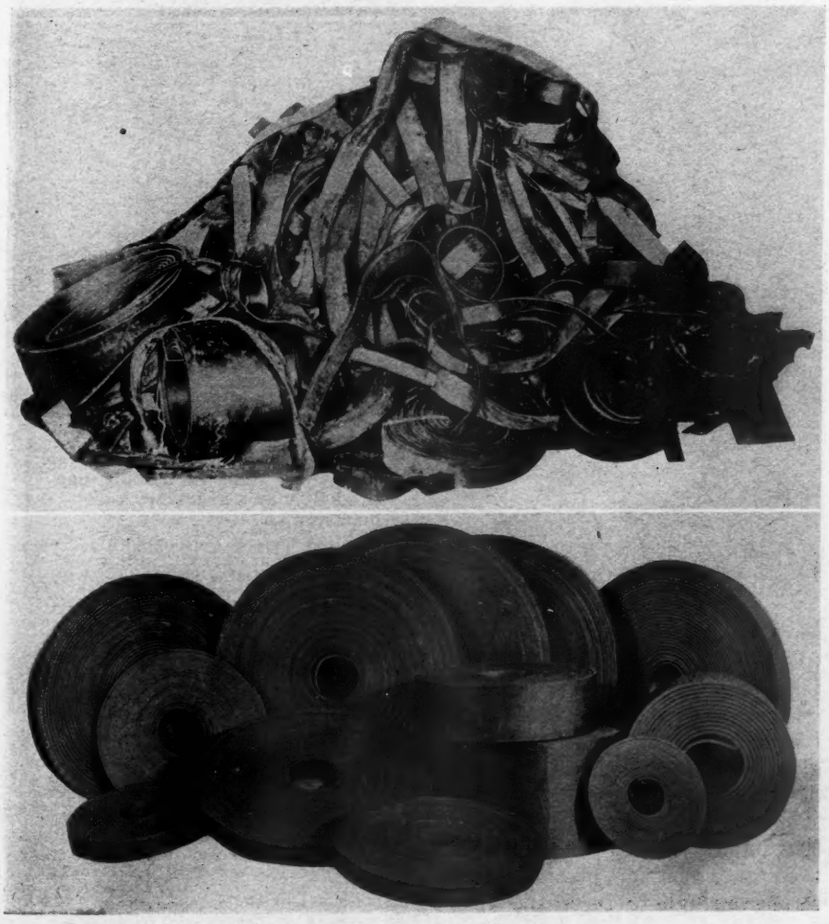
One of the things to look for when a belt is removed from service is to see how badly and where it is worn. It is also necessary to look out for open plies and joints as well as rough or torn edges. Oil and dirt are other factors which interfere with good belt service and should be taken care of before a belt is put back into service. Not only will a dirty belt slip again when returned to service but a belt filled with oil and grease cannot be cemented together properly. If a belt cracks when it is bent double with the pulley side out, this indicates that the belt has been burned by slipping over the pulley or that it is very dry. Ordinarily but little can be done when a belt has been burned except that the damaged sections must be cut out and thrown away. In double or 3-ply belts usually only the ply next to the pulley is damaged. This can be removed and replaced. If the belt is too dry, it can be softened by using a special belt oil. Castor or neatsfoot oil, tallow, or some of the special preparations in stick or wax form can be used for softening belts. This point was covered in the article entitled "Servicing Industrial Belts" which appeared in the May issue of INDUSTRIAL ENGINEER. The greatest trouble in using these generally lies in applying too much oil or dressing, which may be worse than not enough.

WHAT MAY BE DONE TO RECLAIM LEATHER BELTS

One of the most common injuries to belts which an industrial belt man is called upon to treat, is a belt worn on the edge or face. For example, practically all belts that are shifted get thick at the edge. Roller shifters decrease the damage and make a belt last longer on this work. Also, it is not unusual to find a belt rubbing against a board which is put up to keep the belt on the pulley. A belt cannot cut several inches into this board without damage to itself. The remedy here is to align the pulleys or cut the ends of the belt square so that the board is not necessary. This, however, is one of the easiest problems of reclamation for the belt man. Usually with ½ in. cut off the edges of the belt a good serviceable belt of 1-in. narrower width is reclaimed. Of course, there may be other repairs to make such as replacing worn sections or regluing laps and joints. Sometimes, however, one edge is so badly damaged that more than ½ in. needs to be cut away.

Where belts are allowed to scrape or rub, this simply wears away the belt until much of the strength is gone. To repair such a belt it is sometimes necessary to cut a 3-ply down to a double belt by removing one ply or, on a double belt, to make it into a single belt. Usually when single belts are worn away in this manner they are hardly worth repairing although if not too badly worn a ply may be added which gives a strength equal to a light double or heavy single belt. Also, when a belt rubs either on the sides or at the edge, it is likely that the fastening will catch and open up or tear out unless it happens to be a cemented endless belt.

Frequently one of the first steps in handling a leather belt is to clean it. This may be done either on the pulley or when removed, but a belt is much easier to clean and a much better job can be done if it is off the pulley. Belts may be cleaned on the pulley by applying gasoline with a brush or waste soaked in high-grade gasoline or naphtha. Because of static the belt should be idle. Within a few minutes, after the gasoline has had time to soak into the belt, the dirt and oil may be removed by scraping with a block of wood or any blunt-edged tool held so that it will not catch and cut the belt. In some cases it may be necessary to apply more than one coating of gasoline before a belt is clean. This method is not recommended because of the fire hazard. Also many belts are so well guarded that it is almost impossible to get at them to clean in this way and it is unsafe to operate without the guard.



A pile of discarded leather belting and what was made from it.

The maintenance engineer in one industrial plant, rather skeptically sent the 1,726 lb. of junk leather belting shown in the upper of the two photographs to a "Belt Laundry" to see what he could get out of it. He received back the pile of good, usable belting worth at that time $1,300, which is shown in the lower of the two illustrations. There was a loss of 517 lb. or 30 per cent, due to metal belt fasteners, dirt and oil which were removed. Some of this reclaimed belting is still in service, ten years after it was cleaned up. Photographs by courtesy of F. Raniville Company, Grand Rapids, Mich.

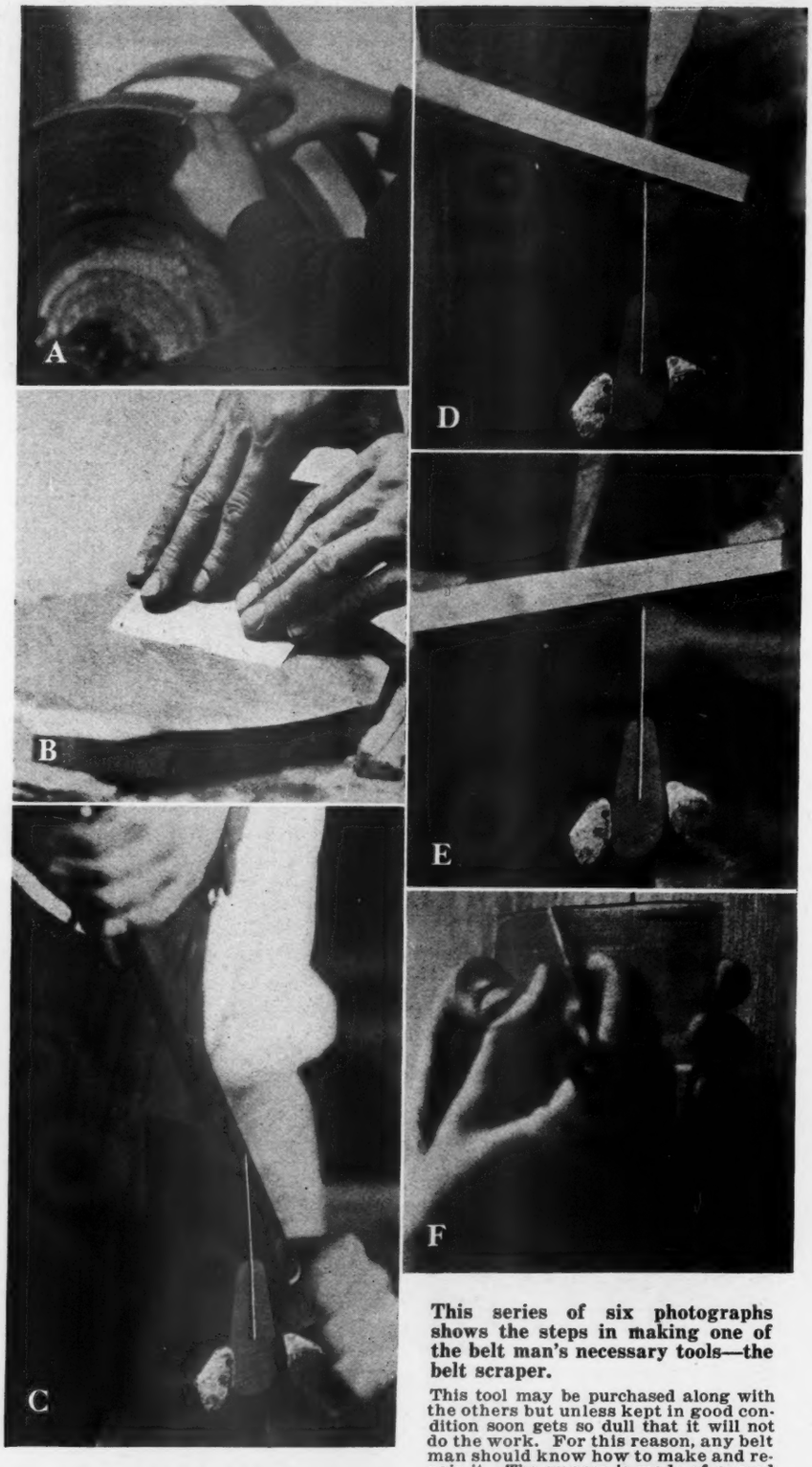
The easiest and best way to clean a leather belt is to roll it up and put it into a can of high-grade gasoline or naphtha or some of the various belt cleaning solutions. A low-grade gasoline will leave some grease in the belt. About 15 minutes is usually long enough to let the belt soak. If left too long the belt is likely to dry out more than is good for it and requires more oiling or "currying" to get it back into shape. Ordinarily a soaked belt does not require any scraping unless it is very dirty. Companies specializing in this work have several different solvents, as gasoline does not remove all impurities; it will not remove one common coating, rosin, which is frequently added to a belt to prevent slipping.

How Joints and Seams of Belts Are Repaired

When the feather edge of the seam opens, as it may if the belt travels with the tip of the lap joint on the outside of the belt pointing against the wind or rubs against any object, the first thing, before making repairs, is to remove the cause; that is, turn the belt or remove the object rubbing it, It does but little good to make the repairs without removing the cause, as they would only have to be repeated shortly. The first step is to pry the opening a little wider with a blunt tool such as a screw driver, clean it out with a scraper and reglue. It is best to tear the joint entirely apart and reglue but frequently it is not desired to stop any longer than necessary. Most belt glues must be applied hot. If the belt is waterproofed special cement must be used. The edges must then be pressed together and rubbed or hammered to remove air pockets. After the glue has been allowed to harden as prescribed by the manufacturer the belt is ready to be placed in service.

Generally it is not necessary to remove a belt from the pulley for this purpose unless it is desired to turn it end for end, or take it off for some other reason.

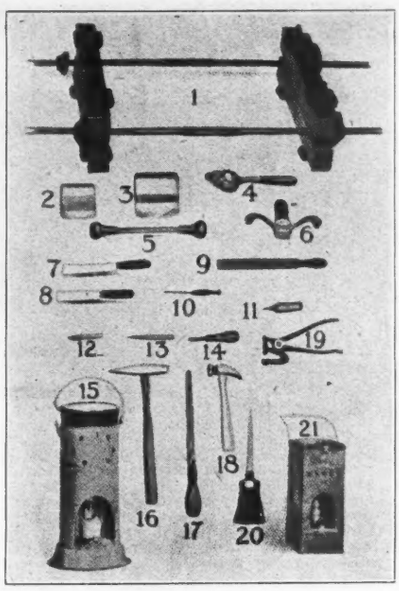
When it is necessary to rebuild a belt by taking off some of the old worn plys and putting on new, it is generally better to return the belt to the manufacturer or to companies which specialize in reclaiming and rebuilding belts as they are better supplied with belt presses and other necessary tools. However, many companies with a large amount of work do this successfully. The first step is to remove the damaged or worn ply by working the seam open with a blunt tool. The glue and torn parts should next be scraped away. The whole surface is then roughed up so that it will absorb the glue better, covered with glue, the new ply added and the belt put into the belt press. There is danger that the small presses which would be used in industrial plants, are not strong enough to force the air out



This series of six photographs shows the steps in making one of the belt man's necessary tools—the belt scraper.

This tool may be purchased along with the others but unless kept in good condition soon gets so dull that it will not do the work. For this reason, any belt man should know how to make and repair it. The scraper is made of a good grade of tempered steel similar to that used in saw blades and fitted into a handle as shown. The edge, however, must be turned at right angles to the blade so that it can be used to scrape to better advantage. The first step *A* shows the method of grinding a thin edge on the scraper on an ordinary grindstone. After this it is finished off, *B*, to a fine edge on a clearing stone. *C*, *D* and *E* show three successive steps in turning the edge. *F* shows the turned edge and the tool which is used to keep it in condition. These photographs are shown by courtesy of The Leather Belting Exchange, Philadelphia, Pa., an association of leather belt manufacturers.

and make a tight joint. Also when these belts are sent to the manufacturer to be rebuilt the industrial belt man does not need to carry a supply of leather of different weights for repairs. This operation is probably one of the most difficult in belt reclamation. Here, as in other steps of reclaiming belts, it often pays to return the belts to a belt manufacturer or to a responsible concern engaged in rebuilding belts. Users, however, should not expect to get wide belts made from short, narrow strips. Also there is a shrinkage—often 30 to 50 per cent—due to metallic fasteners and oil or dirt imbedded in the leather. When a new ply is added the old leather should be used next to the pulley, as it is "broken in," and the new leather on the outside to give strength.



In belt work, as in any other line of maintenance work, a man needs good tools to do a good job.

These tools, many of which belt men already have, while others may be obtained from any manufacturer and most jobbers of belting, are almost necessary for good belt service. Those shown above, as listed by The Leather Belting Exchange, are: (1) Clamps and rods; (2) belt scraper; (3) slicker; (4) belt hoe; (5) belt shave; (6) spoke shave; (7) long skiver; (8) heel chop; (9) knife sharpener; (10) steel sharpener; (11) awl; (12) drive punch; (13) blind punch; (14) staple puller; (15) glue kettle; (16) ripping hammer; (17) screw driver; (18) pegging hammer; (19) hand punch; (20) 3½-in. best glue brush; (21) safety copper glue kettle.

Results of Good Belt Practices in One Industrial Works

The results of the practices in belt work at the Deering Works of the International Harvester Company, Chicago, indicate what may be accomplished through centralized supervision of all belts by competent, practical belt men. Here this work is under direct supervision of H. R. Slivinski, master mechanic. Each oiler looks after the belts on the machines he oils and tightens them up if necessary. When a belt gives way one of the two belt men repair it. The oiler, however, brings the belt to the belt room. This assures the return of the old belt, as another is not given out unless an old one is received. Also, if the belt shows abuse, the cause is discovered and remedied, if possible, before a new belt is put on. If the trouble cannot be removed easily or must be done by some other department, such as repairing leaks in the roof, the trouble is reported to the proper department which makes the repairs. If the belt shows satisfactory service, another of the same size is issued, otherwise, an investigation is made to see if the damage is the result of improper conditions or if a heavier belt is required. The old belts which are received are inspected, cleaned, repaired and reclaimed, if necessary, and stored for future issuance. New machines are installed with new belts but reclaimed belts are issued for replacement, if the proper size is available.

Mr. Slivinski favors good-grade leather belts for most power transmission purposes, and is confident that the better grades are the most economical, especially under severe service. For example, in one case, a large Sturtevant fan is driven by two 7-in. belts at 2,100 r.p.m. The pulleys are 10-in. in diameter with an 8-in. face. The belt speed here is 1¼ miles a minute. The rated speed of the fan is 1,400 r.p.m. This is an excessive overload on the belt and formerly when operated at 1,800 r.p.m., a belt was considered as giving excellent service if it lasted six weeks; most of the belts lasted less than a month. However, now a special heavy double-belt properly made with the backbone cut of the hide in the center of the belt is cemented

Belts stored in orderly arrangements such as this are easily accessible.

This photograph shows one corner of the belt storage space at the Deering plant of the International Harvester Company. Similar racks occupy the opposite side of the room. Each compartment is of a definite width for a certain size of belt and this width is marked at the top of the compartment. One of the first steps after the master mechanic's office took charge of the belt work was to issue all belts from a central storage. They also require that an old belt be returned before another is issued. Reclaimed belts are issued for all except new machines whenever one of the proper size is in stock. The steel cask in the left foreground contains a special belt oil used to keep belts in condition.

endless. While this belt costs about twice as much as any other belt, it lasts a year or more, and so is much more economical in the long run.

Belts operated at high speed, as on wood-working and twine mill service, engines and motor belts, are cemented, endless leather belts. Other leather belts on machines are joined by metallic fasteners of one type or another. Preference, however, is given to a malleable hook with projections which are driven into the belt. If the proper size is used these projections do not extend through the belt, and as the hook is narrower than the belt, it does not offer any obstruction or point on the pulley side or on the edge. This hook is quickly applied—the ends of the belt are cut square, placed end to end on the hook projections which are then driven into the belt with a leather-faced hammer or a block of wood, which protects the points and does not clinch them. This hook may be pried off easily and used again if not clinched. On the outside it has the appearance of a plate and is curved to fit the pulley. Not a single rawhide lacing is used in the plant, because of the time required to lace and the weakening of the belt by the holes cut.

Flexible metallic lacings are used on Balata, rubber, and cotton-woven belts, which are installed under some conditions. For example, cotton-woven belts are used on tempering conveyors which run in an oil bath at 160 deg. F.; rubber and Balata belts are used in wet places, also some special belts are used.

Leather belts which have been returned to the belt room are not only cut down to a narrower width if damaged on the edge, but loose plies are recemented and sections rebuilt in the shop shown in the illustration at the head of this article. Additional belting, both old and new, is carried in a locked storeroom adjoining. The scarfing machine shown in an accompanying illustration originally was built for bench work but has been made portable by the addition of legs on wheels and a removable third wheel and handle which, when attached, lifts the machine and supports it on wheels so that it can be pulled anywhere. The belt press, operated by hand, and the pointing bench are shown in the background. Belt hooks, as well as other fasteners and supplies, are carried underneath the bench.

A collection of the belt tools used at the Deering Works.

This layout of belt tools is sufficient for the belt work carried on at this plant. Almost all of them are familiar to any shop mechanic. The others, those which are special to belt work, may be recognized by comparison with another illustration in this article which identifies each tool. The tool at the extreme left, however, is a leather-faced hammer which is used for driving the malleable fasteners without clinching the points.

Two large engine-drive belts, each 72-in. wide, 3-ply, which last about eight years, are cut down and used on smaller drives and in some cases are cut down and used over several times before they are thrown away. On these large belts it is occasionally necessary to open and remove air pockets between the plys. The joint is opened, the surface scraped and covered with cement, and the ply hammered to remove the air. This is done without removing the belt. Sections of belt which are cut out, because they cannot be used for transmission are cut into brake linings and used for other miscellaneous purposes. The scrap ends, trimmings, and short pieces, which cannot be used in rebuilding belts, are used in casehardening. In this way the belt is entirely used up, with but little waste.

This separate belt department was created in 1909 under the supervision of the master mechanic, and the first year saved several thousand dollars in the value of belt purchased, as compared with the amount for the previous year. A large proportion of this was due to a centralized stockroom and more close supervision over the issuance of new belts as well as in the reclamation and reuse of those belts which were removed. Records are not kept of each individual belt except in the case of the special belts, because of the large amount of clerical work involved, as there are approximately 17,000 belt drives in the Deering Works. Two men handle practically all the work involved. They are in close contact with all belt conditions and soon notice if anything begins to go wrong.

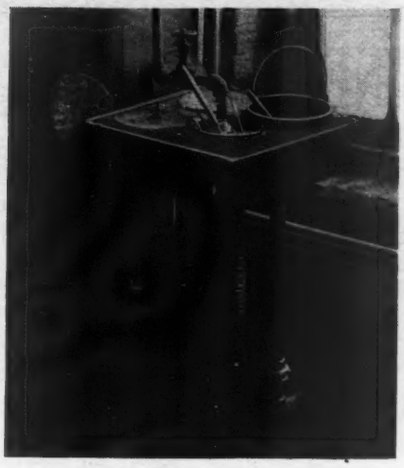
Another feature of this work which is closely related to the belt maintenance is the providing of special coverings for pulleys. Often

Examples of some of the methods of joining belts which are used at the Deering Works.

At the right is shown the machine used for making the first joint. This machine clinches a set of hooks into each end of the belt. The two ends are then hinged together by a rawhide pin. The next belt is fastened by the malleable fastener mentioned in the article. One or the other of these two fasteners are usually used on leather belts which are not made endless. The third belt shows the plate used to join rubber belts. Round belts have a special hook fastener as shown. The belt at the extreme left is a special twisted endless leather belt which is used on some special machines.

when a belt slips slightly because it does not get sufficient grip on the pulley a special covering is added. This is made by adding three or four alternate coverings of a special pulley cement and wrapping with cheesecloth a little wider than the pulleys. The overlapping edge is trimmed off to the edge of the pulley. This gives a surface which grips the belt better and may be applied to either cast-iron, steel or wood pulleys. Also, by using narrow strips of cheesecloth in the center and covering with strips full width a pulley may be crowned or the crown increased.

While many smaller plants could not expect to make such a showing and could not afford to have two men devote all of their time to this work, they could at least have one man devote a part of his time to it. Practically every concern which has put the belt work under the direction of one competent man has found that this has made material savings in belt expense, without considering that real but intangible saving made through decreased shutdowns and increased production.



This steam-heated glue pot supplies glue for cementing belts on work done in the belt room.

This glue pot is placed at the extreme end of the belt bench shown in one of the accompanying illustrations. Where belts are cemented out in the shop the portable glue pot, shown in the group of tools in an accompanying illustration, is used.

How to Make a Belt Scraper and Keep It in Proper Condition

One tool, the belt scraper, which belt workers use as much or more than any other is, because of its construction, a little more difficult to make and keep in shape. In some instructions on making belts endless issued by Louis W. Arny, secretary, The Leather Belting Exchange, Philadelphia, Pa., this tool is described and illustrated along with other tools for making leather belts endless and for doing industrial belt work.

The weak point of every belt is the joining of the two ends. Not only is it the weak point, but also it is the point of most belt trouble. There are a multiplicity of devices for joining these ends, from the old lace-leather-sewn joint, to the endless variety of metal fastenings. Some of these are better than others. The remedy for all this annoyance lies in using only endless belts, that is, those in which the two ends of the belt are joined to make a continuous length. Some belts can be made endless on the pulleys satisfactorily, and some cannot. This paper applies only to leather belts which can be made endless on the pulleys satisfactorily.

The tools required for this are illustrated and listed in one of the illustrations on page 307. Some of these tools already are in the shop, and all of them, or any of them, may be obtained from any leather belting manufacturer. Only one of these, No. 2, is unusual to the ordinary mechanic—the turned edge scraper. This is a flat piece of good steel, about the thickness and quality of good saw steel, and is fitted in a handle as shown. The point about this tool is that it works with an edge which is turned at a right angle to the blade. This is accomplished by grinding a long edge, then rubbing this down to a fine edge on a "clearing stone," then with a smooth, hard steel tool, turning this edge so that its cutting edge is at right angles to the blade. With the tool firmly held in a vise, pressure is applied on one side, about at the angle shown. When the edge is smoothly and uniformly turned to the angle shown, the angle of the steel tool is changed, and the process repeated, and then is completed by using the steel tool at right angles to the blade. The steps in making this tool are shown in a group of illustrations on page 306 of this article through the courtesy of The Leather Belting Exchange.

A small steel tool, No. 10 in the illustration, which is round and slightly tapered with a smooth, hard point is used to keep this turned edge in good cutting condition, by rubbing its point on the under side of the turned edge, and its surface on the upper side. These turned edges are fairly durable, in working in leather, but when they are gone it is necessary to grind the tool again, and repeat the process of forming the edge.

While working on the lap of the belt with this scraper, the belt is held by a special clamp as shown in the illustration on page 304, where the man at the right is using a scraper. The end of the belt is held down by an eccentric roller so that it acts like a cam and clamps the belt on a glass plate which protects the scraper. An advantage is that it can be quickly clamped or loosened.

The scraper is one of the most important tools in the belt maker's kit, because it saves much time in cutting laps, and because with its use it is easy *(Continued on page 324)*

One of the handiest machines in the Deering belt shop.

This scarfing machine for putting a beveled edge on leather belts for making a lap joint when a belt is cemented endless, was originally built for bolting to a bench. For greater convenience, the Belt Repair Department mounted it on legs and wheels as shown. By the addition of a pivoted third wheel and handle it may be pulled to any part of the shop where a belt is being put on. Whenever possible it is used in the belt room.

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, June, 1923

Wasting Ten Dollars to Save One

WHEN buying equipment the old question of price *vs.* quality almost always comes up. It is assumed that a higher price does not always mean better quality, but usually equipment prices, like those of other commodities, are based on what it is worth to the user and cannot for long be out of proportion to competitor's prices.

One argument which may be used to defend a larger expenditure for better equipment is that the purchase price does not represent an item which is used up and gone, but one which has an estimated useful life or service of say ten or more years. In that case, an extra $100 on the purchase price would mean only $10 a year. Perhaps the operation or processes dependent upon the reliability of continuous operation of the new equipment is such that any interruption of service would be expensive due to, for example, freezing of metal, clogging of a conveyor, or destroying of work or materials in process, or other similar conditions. In such a case isn't a greater assurance of reliability worth at least $10 a year? One failure might be many times as expensive. For that matter, every dollar saved may mean an expenditure of ten or more to make up for it.

Protection Against Things Seen and Unseen

RULES and regulations covering the installation of motors to eliminate as far as possible fire and accident hazards and possible injury to operators or unauthorized persons are now quite generally known and observed. Similar regulations that will protect the motor itself from injury arising from conditions or operations near it are not so generally observed.

Motors are found in pits where considerable moisture is present, in surroundings where the temperature is continuously high, where dust and dirt accumulate from operations on the machines they drive and various other conditions which penalize the performance of an electrical machine as a production unit and reduce its ability to carry the load for which it is rated by the manufacturer. Such conditions give many good motors a black eye in the estimate of the operator and the man responsible for its maintenance when, as a matter of fact, the trouble signs it shows point directly to a failure to exercise common sense when making the installation.

A couple of illustrations will be sufficient to bring out these points. In a certain plant sanitary requirements demand that the floors and machines shall be thoroughly washed each day. This operation is done by hot water from a hose in the hands of a clean-up man who has no knowledge of electrical machinery and hardly knows a motor from any other piece of machinery. His is a clean-up job and he plays his hose on the motor attached to the floor with the same violence as he does any other spot. In another plant where combustible material is present and fires are liable to start, which are checked by an overhead sprinkler system, the motors are protected by a metal roof type of shield. In this plant when a sprinkler head lets loose the motor is seldom injured by the spray of water.

In both cases open-type motors are used and attached to the floor but in one case a high and regular maintenance cost is created while in the other a less liable but possible maintenance cost is prevented. Both installations provide an opportunity to exercise plain ordinary horse-sense that will return a handsome saving in preventable waste of repair time and expense through simple schemes of protection that take little time to apply and cost only a small part of the expense of one complete repair job on an injured motor.

Protection is a term whose meaning can be effectively studied in every works from a wide variety of angles. We hope our readers who have done this will send to INDUSTRIAL ENGINEER the results of their findings and suggestions for conducting the investigations we now have under way that will cover practices or operating conditions on which they would like to get information from other readers.

What Is the Cost of a Repair Job?

CONSIDERABLE pride is taken in a repair shop when things are so organized that experienced men can do the work at a low cost per job. And in most shops a detailed record of costs is kept that shows labor and materials used and that troublesome item of overhead around which many argumentative wars have been and always will be waged. But there is a larger and more important element in repair costs that is regularly overlooked. It is the loss resulting from productive machinery standing idle during a repair job or until trouble can be located and the machines started again.

This is an item in repair costs that belongs in every cost record of a maintenance department for it will place responsibility for causes of repairs and give credit in keeping them down just where it belongs. If maintenance records show prevention of repairs through keeping this loss down, they are the finest recommendations for the ability of the men who are charged with the responsibility to find small troubles before they become large. If this loss is high it directs attention to two things. First, lack of adequate inspection and,

second, abuse of machines by operators, or faulty installations.

High repair costs that can be traced to abuse of machines is an item that should be credited to the maintenance department, not charged to it, but unless repair records show the causes that create repairs and the losses attached thereto, a true minimum of repair costs can never be reached nor can a just credit be awarded to the man who knows how to prevent trouble as well as how to remedy it.

Do You Burn Clothes When They Are Soiled?

IN an article in this issue on the subject of belts, it is pointed out that approximately 65 per cent or more of the belts thrown away in industrial works have useful life in them which may be utilized. The operations required to reclaim old belts are not difficult. However, if it is not desired to do this in a plant, the old belts may be gathered together and shipped to companies which make a specialty of overhauling waste belting and putting it back into shape. The cost is much less than new leather belt and the belt when it is returned has a number of years of useful life still in it. Such a plan is worth trying and it is, at least, preferable to burning this leather belting in a furnace, and thereby getting nothing for it.

Of course it is not expected that small pieces and narrow widths, a foot or two long can be worked up economically into good belts. However, most belts that are discarded are much longer than this. Because a belt is full of oil and dirt is no sign that it is absolutely worthless. This can be cleaned by soaking in the proper solutions in much the same way that clothes are cleaned. Many companies who have made a practice of reclaiming their belts have found that they have made a saving of 15 per cent or more annually in their belt bill. We would not think of throwing away our clothes when soiled—why change our thinking when it comes to belts?

Use Little Ones to Catch the Big Ones

CLIPPING one-half of a turn, which amounts to about one-eighth of an inch, from the coil formed by twisting the vertical strands to the horizontal strands of woven wire fencing, might not appear to be worth doing, from the standpoint of saving wire. But many millions of such coils are made in a year and by clipping the ends in this way one large manufacturer of wire fencing saves $40,000 annually, without decreasing the strength or usefulness of the product. An idea that the platinum contacts used in telephone apparatus could be welded to the contact springs and thus save the shank of the platinum rivets then used, resulted in a saving of $200,000 or more a year. The platinum saved in each contact was much smaller than the head of a pin—but many millions of contacts are made in the course of a year.

Millions of dollars have been made or saved, by spectacular and revolutionary schemes, but no doubt just as many or more millions have been saved, in the aggregate, by paying close attention to the little things. After all, everything from the most complicated machine to life itself is made up of a lot of little things. On the surface, a fifteen-minute shutdown through interruption of power service merely gives the operators a little chance to discuss baseball or fishing with their neighbor workers. But wages and overhead go on just the same whether or not the wheels turn and one such interruption a week makes a surprising total of time and money lost in a year. The lack of an effective method of caring for and checking out material from the storeroom will almost inevitably result in many leaks and losses which, although they may be small individually, are collectively too large to be neglected. Instances such as this are to be found on every hand. All that one needs to find them is an investigative turn of mind and an unwillingness to believe that, because a thing has always been done a certain way, that way is necessarily the best way of doing it.

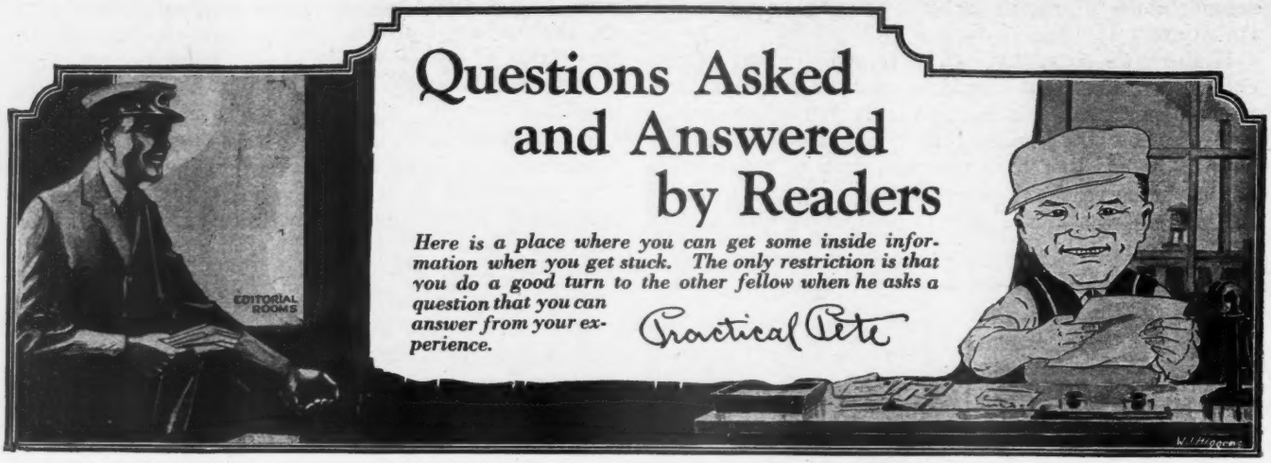
The author of the proverb: "Take care of the pennies and the dollars will take care of themselves," stated a proposition whose truth is not limited by the times or circumstances.

Service Around the Works

TIME is passing, and very rapidly, when department heads and foremen in industrial plants are paid for the hours of work the time records show. Production schedules are so closely laid out and so much depends upon the judgment of foremen and department heads that they are becoming specialists in the kind of work handled from a production standpoint. They are not only responsible for the quality of the work turned out as measured by certain plant standards but they are responsible for the effectiveness with which material and labor are used and their ability to keep the rate of production at a maximum under all ordinary conditions.

Among these men who are responsible for plant production is a relatively small group whose function and importance are growing day by day. This group is particularly responsible for continuity of power service and the mechanical handling of parts in process between machines and between departments. These men have a wide variety of titles but their responsibility is that of continuity of operation and maintenance and the elimination of breakdowns and shutdowns that can be anticipated.

The range of operation of these men, in the majority of cases, is as broad and as long as the plant itself and they are men who by training and experience are not only looked upon as experts in determining the condition of equipment in operation, but who are looked upon for a kind of judgment that compares with the judgment of a physician who diagnoses ailments of the human mechanism and administers preventive and curative treatment. The same measure of success that comes to a physician as a result of good judgment in diagnoses comes to the man responsible for operation and maintenance and when he combines initiative with an expert knowledge of maintenance methods he is paid—not for what he does day by day—but for what he knows and the results he can secure and he is creating for himself a position in the industry which is rapidly becoming recognized as an important division of production engineering.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Cleaning Gold, Silver and Nickel—I would like to have readers describe methods they are using to clean gold, silver, nickel, etc., by using a. c. current. Please give kinds of solutions used and a sketch of the outfit.
Elgin, Ill. L. W. B.

* * * *

Voltage between Transformer Neutral and Ground—I am looking for information which I am sure some of our readers can furnish. In a primary star connection with the neutral grounded, machine rating 4,000 volts, three-phase between phases, what voltage, if any, would there be to ground when three single-phase transformers of 2300-volt rating are star-connected to the primary side and the secondary side connected 440 volts delta? Also, what would it be if the secondaries were connected 440 volts star on the secondary side?
Elkhart, Ind. R. A. D.

* * * *

Requirements for Grounding Conduit—I would like to get some information on practice in grounding conduit. Has the section of the National Electrical Code, 1920 edition, paragraph F on page 27 of section 12 on wires covering class B outside work been changed? I refer to the ruling regarding short lengths of conduit for entrance wires. Formerly where only a few inches of conduit were used to make an entrance it was not required to ground this conduit, providing no conduit was used inside the building and the voltage was less than 150 volts. We are now required to ground all such conduit to a 1-in. gas pipe, which seems unreasonable and adds at least four or five dollars to the job. I would like to hear from other readers who have run into requirements of this kind.
Good Hope, Ill. V. W. M.

* * * *

Charging Ford Magneto Magnets—I should like to know how to charge the permanent magnets on a Ford magneto without removing them from the car. I have tried passing current through the armature coils, but had only two 6-volt storage batteries and these did not make the magnets strong enough to hold up very long.

Can some reader advise the voltage needed to produce the required current through the coils and the length of time the coils should carry current to produce the proper magnetism.
Moundsville, W. Va. J. W. M.

* * * *

Reducing the Speed of A. C. Motor—We have a 20-hp., 440-volt, 3-phase, 60-cycle, 1160 r p. m. motor having 36 coils. Each coil has ten turns of two No. 11 wires. The coils lay in slots 1 and 11 and are connected in series-star. We want to change this motor to operate at 860 r. p. m., 440 volts, 3-phase, 60-cycles, and still develop 20 hp. with seventy-two coils. The stator is 13 in. in diameter with seventy-two semi-closed slots ⅜ in. wide by 1⅛ in. deep. The core width is 6 in. We have already wound this motor with seventy-two coils made of five turns of two No. 11 wires. The coils were placed in slots 1 and 8 and the group connected in series-star. On testing the motor we found that it ran 900 r. p. m. but took 44 amp. at 480 volts running idle, although it did not heat up much. Will some reader please tell us what size wire and how many turns per coil we should use?
Mansfield, Ohio. C. E. P.

* * * *

Reversal of Rotation of Watt-hour Meter—There are two questions I should like to ask the readers of INDUSTRIAL ENGINEER.

(1) We have an Ingersol-Rand compressor, driven by a Westinghouse synchronous motor. When this motor is started by an auto-starter the watt-hour meter will run in a forward direction, but as soon as the switch is thrown into the running position, the meter reverses its direction of rotation. By adjusting the field excitation up to 20 amp. the meter will run forward or in the proper direction, but as we have to run this motor with a field excitation of 35 amp. the meter will again reverse and run backward as soon as this current value is reached. This is a polyphase, watt-hour meter and the power factor never goes below 70 per cent. What causes this reversal?

(2) We are about to install four 300-hp., 2,200-volt, 3-phase, 60-cycle motors rated at 69 amp. per motor, or a total of 276 amp. What size polyphase watt-hour meter should be purchased in order to take care of the four motors?
Iron River, Mich. A. J. E.

Answers Received To Questions Asked

Expansion and Contraction of Steel Trolley Bar—What allowance must be made for expansion and contraction, due to changes in summer and winter temperatures, of a steel trolley bar 625 ft. long on an outside crane runway? This will be a (10 point carbon composition) rod 0.342 in. in diameter with supports 10 ft. apart. What is the best method of anchoring this rod to allow for this expansion?
Gary, Ind. A. L. G.

In the January issue of INDUSTRIAL ENGINEER, A. L. G. asks what allowance should be made for expansion and contraction in a steel bar used as a trolley wire for a crane. He did not state whether the bar was to be installed entirely indoors or out-of-doors, or whether it would be partly sheltered and partly exposed to the extremes of temperature; about the only data given was that it was to be 625 ft. in length.

The writer has had no experience with steel bars used in connection with cranes, but has had experience with several miles of such construction, under which trolley cars are operated. The expansion of 625 ft. of steel bar, even if installed out-of-doors, where the changes might amount to perhaps 100 deg. F. will not be very great and, if the construction is indoors, should be considerably less. The co-efficient of expansion of steel is only 0.00000633 per degree F., or 0.000633 for 100 deg. Then 625 ft. would expand 0.395625 ft. (say 0.4 ft.) for a 100 deg. change in temperature.

Since 0.4 ft. equals 4.8 in., if the bar were anchored at its middle point the expansion in each direction would be only 2.4 in. for the full 100 deg. of temperature change. However, the bar should be installed when the temperature is about midway between

the two extremes and then its change in temperature would not exceed 50 deg. either way, or 1.2 in. change in length.

We install our trolley bar with slotted holes to permit of expansion and contraction, using a ⅝-in. bolt in the hanger to support the bar. The greatest length of the slot needed would then be ⅜ in. for the bolt and 2.4 in. for expansion, or about 2¾ in., placing the hangers so that the bolts would be in the center of the slots at the start, and thus giving 1.2 in. on each side of them for movement.

If the holes for the three hangers nearest to the center of the bar are drilled round, and of the proper size to just fit the bolts, so that there is no allowance for expansion or contraction, they should prove a strong enough anchor to prevent any movement of the bar at that point.

Westfield, N. J. G. H. McKELWAY.

* * * *

Winding a 1 to 1-Ratio Transformer—I want to wind a 1 to 1 transformer for 110 volts primary and 110 volts secondary and apply both primary and secondary wires at the same time. This would put the secondary winding in contact with the primary winding through the entire length with no other insulation between them, except that which is on the wire. What insulation would it require to withstand the stress for this kind of an arrangement? Would it require enamel and double cotton, enamel and single cotton or would double cotton be sufficient?

If I understand it correctly, when the primary pressure is a maximum the secondary pressure is zero, and when the secondary pressure is maximum, the primary is zero. Is this correct? If so, the emf. or current would not pass from one winding to the other, except when the secondary was grounded.

Logansport, Ind. L. E. G.

Double-cotton-covered wire will be satisfactory for winding it. Double cotton as applied to copper magnet wire punctures at 150 volts, approximately, but if the wire is reinforced with a good varnish this value will be increased to approximately 500-600 volts.

In this winding there is no danger of a flashover between adjacent primary and secondary wires, but the point to reinforce is between layers. The longer the coil the greater will be the difference of potential between the first turn of the first layer and the last turn of the second layer, as shown in the diagram.

Assume 2 volts per turn, then the voltage between conductors 1 and 2=2 volts, between 14 and 15=30—28=2 volts, between 1 and 28=56—2 or 54 volts, between 6 and 23=46

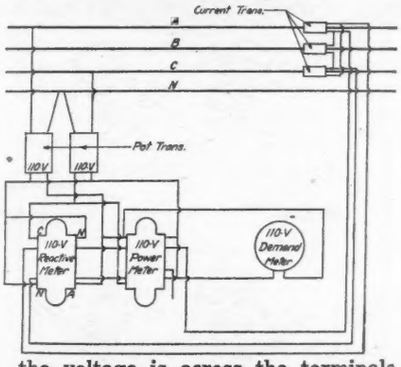
Transformer winding should be insulated between layers.

—12 or 34 volts. Hence the longer the coil the more turns per layer and the greater difference of potential between the start and finish of each layer. It is necessary to insulate between layers with 0.004 or 0.007 fishpaper. A. C. ROE.

Detroit, Mich.

* * * *

Voltage at Meter Terminals—The accompanying illustration shows the wiring for meters in our plant. I would like to have some reader check these connections and indicate what



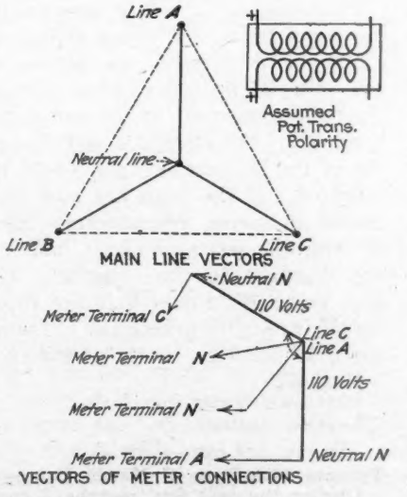
the voltage is across the terminals of the reactive meter at the following points: C to N, N to A and C to A.

Racine, Wis. T. G. L.

In answer to the question by T. G. L. on page 158 of the March issue of INDUSTRIAL ENGINEER, I submit the accompanying diagram which gives the vectors of the voltages across the meter terminals.

C. OTTO VON DANNENBERG.

New York, N. Y.



Vector diagram of voltages across terminals of reactive meter.

In answer to the question asked by T. G. L., in the March issue, with the connections as given, the voltages at the meter terminals will be C to $N = 110$ volts; N to $A = 110$ volts; C to $A = 190.3$ volts. This is because the common is connected to the neutral, thus making the voltages A-N and C-N actually only 60 deg. apart, or 110 times $1.73 = 190.3$. This diagram is usually limited to the use of zero-center, indicating wattmeters to indicate reactive kva. and is not the correct one to use for the measurement of kva.-hrs. unless its limitations are clearly recognized. For example, on a circuit where the power factor may be sometimes leading and sometimes lagging, the meter may register first positive and then negative, making its total recording zero unless it is provided with a ratchet register. When the meter is calibrated as a straight watt-hour meter and then is used with this connection, its registration must be multiplied by the constant 0.866 to get true reactive kva.-hrs.

Summit, N. J. VICTOR H. TODD.

* * * *

Dielectric Constants for Insulation—In the February issue of INDUSTRIAL ENGINEER, J. B. Rakoske answered the question by L. E. G. and gave the dielectric constant for paper as 2. I would like to obtain a table of dielectric constants for all insulating materials used with motor windings. Perhaps this information has been compiled and some reader can tell me where to find it.

Brooklyn, N. Y. H. D. D.

Concerning the dielectric constants requested by H. D. D. in the April issue of INDUSTRIAL ENGINEER, I submit the following values:

Asphalt	2.7
Varnished cloth	3.5-5.5
Fiber	2.0
Fullerboard	7.5
Fullerboard, varnished	2.9
Mica	2.5-6.00
Micanite	2.5-6.00
Paraffin wax	1.9-2.3
Paper	1.5-2.0
Porcelain	4.0-6.0
Rubber	2.0-3.0
Rubber compounds	3.0-4.0
Shellac	2.75

These values are taken from Prof. Clarence V. Christie's excellent volume, "Electrical Engineering."

Detroit, Mich. JOHN B. RAKOSKE.

* * * *

The following data may be of service to H. D. D. whose request for a table of dielectric constants appeared in the April issue of INDUSTRIAL ENGINEER. The specific inductive capacity of various dielectrics vary with the shape, size, temperature, and so on, and by the manner in which the stress is ap-

plied. The values given below are safe averages for ordinary conditions:

Air	1.00
Paraffined paper	2.00
Glass, common	3.00
Hard rubber	2.50
Gelatine	4.00
Kerosene	2.00
Mica	6.00
Bakelized paper	5.00
Glass, light flint	6.50
Celluloid	4.50
Porcelain	4.25

Plant Engineer, S. G. ST. CLAIR.
Kilbourne & Jacobs Mfg. Co.
Columbus, O.

* * * *

In answer to the question by H. D. D. in the April issue, some time ago when making some radio experiments I found a table of dielectric constants covering some of the materials used as insulation. The dielectric constant $=K=C^n \div C^{air}$

Substance	Value of K
Mica	4-10
Hard rubber	2- 4
Paraffine	2- 3
Paper, dry	1.5- 3.0
Paper treated as used in cables	2.5- 4.0
Shellac	3- 3.7
Celluloid	7-10

I trust that the above data may be of some service to H. D. D.

Boston, Mass. A. L. MORLEY.

* * * *

Changing Connections of Motor Fields—I would like to see a diagram showing exactly how to change a 220-volt d. c. motor for operation on 110 volts. The present speed is 900 r.p.m. and the rating of the motor is 60 hp. What will be the horsepower at 110 volts and the speed? Will it be necessary to change the armature winding? If so, please indicate the changes necessary. The motor has six field coils.

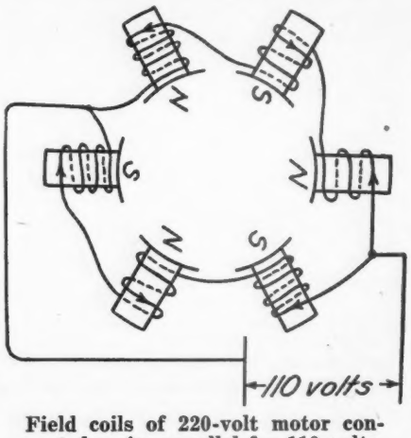
Emaus, Pa. J. A. K.

In reply to the question by J. A. K. in the April issue, the shunt field of the 220-volt, 60-hp. motor may be reconnected for 110 volts by dividing the coils into two series circuits and connecting these in parallel. The motor may then be operated on 110 volts with the armature winding remaining the same, but the speed will be reduced from 900 to 450 r.p.m. and the power to 30 hp. The speed may be increased to about normal by inserting resistance in the shunt field circuit, but the horse-power will not be changed. If the motor must develop 60 hp. at 900 r.p.m. on 110 volts, it will be necessary to rewind or reconnect the armature so that it will have one-half the number of conductors in series per path through the winding and two times the number of pairs, or two times the current-carrying capacity per pair. Before making this change, the brush rigging and commutator should be checked to be sure that the armature current, which will now be double its former value, can be commutated.

W. E. PAULSEN.
Des Moines, Iowa.

* * * *

In reply to the question by J. A. K. in the April issue of INDUSTRIAL ENGINEER, I would say that after changing the winding on his motor the horsepower and speed will be practically the same. The field coils should be connected in series-parallel as shown in the diagram. The armature will have to be rewound, using half the present number of turns and twice the present size of wire. Also, he will have to make sure that the commutator and brushes will carry twice the original current without over-heating.



Field coils of 220-volt motor connected series-parallel for 110 volts.

The current density of carbon brushes should be from 40 to 50 amp. per sq. in. and for copper brushes 150 to 175 amp. per sq. in.

Americus, Ga. B. BELCHER.

* * * *

In answer to J. A. K.'s question in the April issue, regarding changing a 220-volt d. c. motor to operate at 110 volts, if it is desired to obtain the full horsepower of the motor rewinding of the armature and changing of the field connections would be required. If the fields are now connected in series, reconnecting them in multiple-series without making any changes in the armature will give you a little over half the rated horsepower, with practically the same speed as before. C. M. FLUKE.

Manager,
Raystown Water Power Co.,
Roaring Springs, Pa.

* * * *

Trouble with Type C Mazda Lamps—During the last few months I have been having trouble with 100- and 200-watt, type C, Mazda lamps burning out. In about 50 per cent of the cases when the 200-watt lamp burns out, it short circuits where the lead wires go through the inner glass tube down to the filament. I have had four cases where the outside globe has been bursted. When this trouble started, I thought it was due to vibration but have since found that this is not the cause as lamps attached to heavy I-beams show the same trouble. This trouble does not occur quite as often with the 100-watt lamps. In both cases when this trouble comes up the fuses in the circuit are blown. Our operating voltage is 230 d. c. and we use 240-volt lamps. Has anyone experienced this trouble and found a remedy?

New Orleans, La. P. B. A.

I should like to reply to the question by P. B. A. on page 210 of the April issue of INDUSTRIAL ENGINEER regarding trouble with Mazda C lamps. Generally speaking, there is always more trouble with incandescent lamps on 220-volt circuits than on 110-volt circuits. There are two general reasons for this: (1) Difficulty in handling 220 volts and above in incandescent lamps; (2) a large percentage of 220-volt circuits are direct-current circuits.

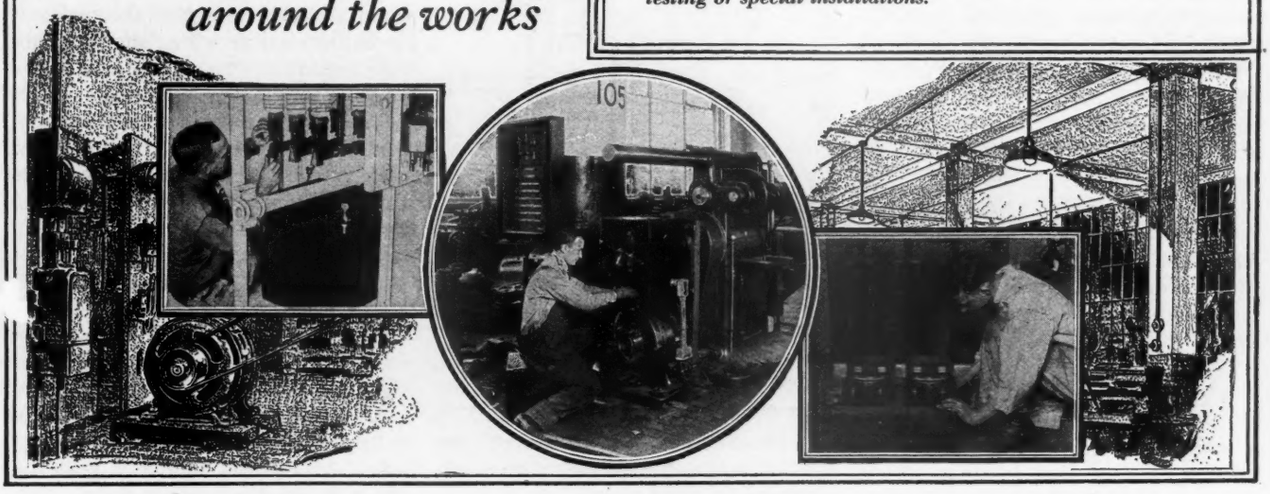
The usual advantages in electrical equipment resulting from higher voltages do not obtain in the case of incandescent lamps. The carrying of high-voltages through the base and the glass stem into the lamp and the mounting of sufficient filament in the lamp present difficulties which persistent effort on the part of the lamp manufacturers has never been able entirely to overcome. This is borne out by the fact that, wattage for wattage, the 220-volt line is more expensive than the 110-volt line and also less efficient. This condition is made worse by the fact that a large proportion of 220-volt circuits are direct-current circuits. Even though a lamp may fail in a perfectly normal way by filament burnout after crystallization, the abrupt cutting off of current frequently produces an arc which persists, due to the unidirectional flow of direct current, until enough tungsten has been volatilized and electrical energy dissipated to create considerable heat.

The proper fusing of 220-volt circuits serving incandescent lamp loads, especially in the case of direct current, will do very much to protect the lamps in such cases as are mentioned in the inquiry. The elimination of 220-volt circuits for lamp loads, just as far as possible, has become general practice in new installations.

CHESTER L. DOWS.
Engineering Department,
National Lamp Works of G. E. Co.,
Nela Park, Cleveland, Ohio.

SERVICE
around the works

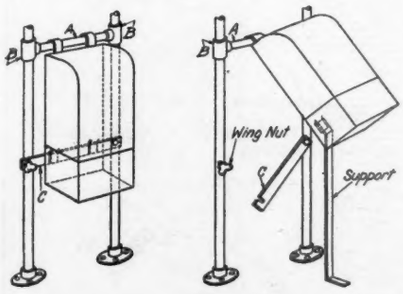
For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



One Method of Mounting Compensator to Make Repairs Easier

THE ACCOMPANYING illustration shows how a Canadian General Electric compensator can be mounted so that repairing of contacts and so on will be much easier. As will be seen, the compensator is hung on a pipe, *A*, that is screwed fairly loosely into the two tees, *B*, in the upright pipe support. The compensator is held rigid at the bottom by a flat iron bar, *C*, which is pivoted on one leg of the supporting frame and secured under a wing nut on the other leg.

For inspection or when it is necessary to do any work on the compensator the bar, *C*, is loosened by unscrewing the wing nut and allowed to drop down from under the hook bars on the back of the compensator. The compensator is then swung upward from the bottom and a heavy stick, piece of pipe, or other suitable support placed underneath it to hold it up out of the way while work is being done.



The compensator is supported at the top on a cross pipe in an upright frame and held rigid at the bottom by an iron strap which can be removed to allow the compensator to be swung upward for inspection or to facilitate repairs.

J. H. SAUVE.
Timiskaning, Quebec, Canada.

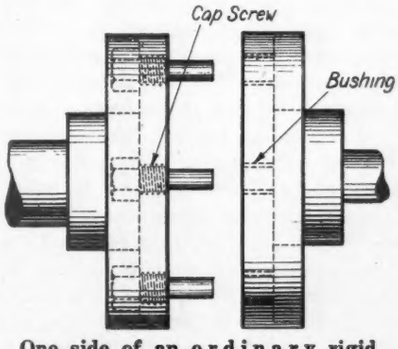
Magnet Facilitates Recovery of Small Iron Parts From Plating Tank

IN THE electroplating department where small iron castings are finished, often small parts accidentally fall to the bottom of the plating tank and must be recovered at once in order to complete a certain lot. Inasmuch as these tanks are approximately 4 ft. deep, it is sometimes difficult to get the parts out. An easy way of doing this, however, is to use an electromagnet wound on the end of a long rod and energized by the 6-volt current from the plating tank busbars. In making a magnet for this purpose, wind about 2 lb. of No. 16 bell wire, 1 lb. on each side, of a horseshoe-shaped iron bar 6 in. long. After the coils are wound they should be made waterproof by giving them two or three coats of P. & B. motor varnish. Such a magnet will lift a large number of small parts. A rod long enough to reach to the bottom of the tank, so that the operator will not get his hands into the solution, should be welded to the magnet. If the two leads from the magnet are tipped with spring clips or clamps they can be readily attached to the busbars of any tank and thus be used when and where needed.

H. S. RICH.
East Berlin, Conn.

How to Make an Inexpensive Flexible Coupling for a Special Job

A FLEXIBLE coupling for a centrifugal pump drive was recently made by the writer from an ordinary rigid coupling. This device, which possesses several desirable features, is giving excellent service, and might be adapted to a variety of drives where a coupling of slight flexibility is desirable. For making this an ordinary rigid coupling of the proper size for the drive was selected and the hubs bored to fit the shafts. As will be seen from the accompanying illustration, the four bolts were then removed and the bolt holes on one side provided with female threads. The bolt holes on the other side were bored to a slightly larger size and brass bushings shrunk into them. Four cap screws were then made up with the threaded portion long enough to fit the threaded half of



One side of an ordinary rigid coupling is fitted with cap screws which work loosely in brass bushings in the other side of the coupling.

the coupling and provided with an extension turned down to a slightly smaller diameter than the holes in the brass bushing in the other half of the coupling, into which they fit loosely and thus give the desired amount of flexibility.

This coupling possesses the advantage that it does not interfere with the easy removal of the motor or driven machine either by sliding or lifting out after the four cap screws are removed, and also that the only wearing parts, the brass bushings, are easily renewed when they become worn down more than is desirable. FREDERICK KRUG.

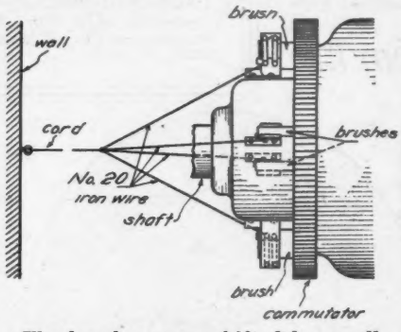
Comerio Falls,
Bayamon, Porto Rico.

To Maintain Service Brushes on Repulsion-Induction Motor Shifted by Hand

SOME time ago a 2-hp., single-phase repulsion-induction type motor failed at a critical time through the breaking of the brush-shifting ring on the spring barrel. This was due to unsymmetrical wear of the shoulder on the spring barrel, causing severe binding and jamming of the ring. Inasmuch as this motor could not be spared from service and no other motor was available, it was decided to remove the shifting ring entirely, since its purpose was merely to remove the tension of the brushes and thus reduce wear on the commutator.

The motor operated satisfactorily, but the noise due to the permanent contact of the brushes on the commutator was unbearable, as the motor was in the basement of a fine residence. Therefore, some way had to be devised for removing the brush tension. Accordingly, four pieces of No. 20 iron wire were attached, one to the lower outer stud of each of the four parallel motion fingers, as shown in the accompanying illustration. The other ends of the wires were tied to a stout cord and fastened to a screw eye in a nearby wall. Inasmuch as this motor was always under manual control, this scheme worked out all right. When starting, the brushes were allowed to make contact with the commutator. After the motor came up to speed and the commutator was short-circuited by the short-circuiting weight, the brushes were pulled away slightly by means of the cord which was then made fast.

No harm could result from this arrangement because if by chance the switch were thrown in while the brushes were out of contact with the commutator, and the short-circuiting weight was out of contact, no current would flow as the rotor would be open-circuited.



The brushes were shifted by small wires attached to each of the parallel motion fingers and tied to a cord which passes through a screw eye fastened to the wall.

HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.,
Patchogue, N. Y.

Four Methods of Turning Conduit in an Emergency Without a Pipe Wrench

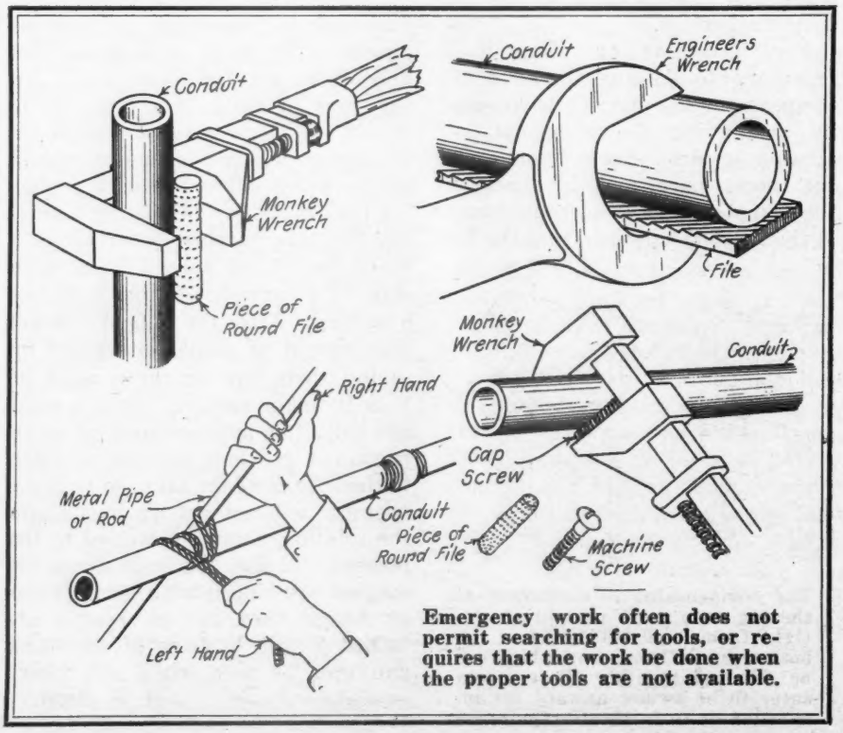
WHILE good workmen want good tools, and the proper tools to do a good job, it is also a sign of a good workman if he still can do a presentable job in an emergency with makeshift tools. For example, while none of the four methods of screwing or turning conduit or small piping shown in the accompanying sketch would be recommended for regular practice, still, for emergency work any of them might serve a good turn. Doubtless numerous other ways would occur to many of the readers for doing similar work, should occasion require. One advantage, however, of these four methods is that the necessary tools and the attachments can be found in almost any location even though a pipe wrench is not available. G. F. H.

Chicago, Ill.

Using a Float on High and Low-Water Alarm for Water Tank

AN ALARM which signals in case of either high or low water is in use on a tank in a St. Louis factory. A red light indicates that the water is at the lowest permissible level and the pump must be started. A green light shows that the high level has been reached. As shown in the accompanying sketch, a wooden drum is mounted on a shaft made of ¾ in. brass tubing and has four turns of cotton cord to the ends of which are attached a copper float and an iron weight. One end of the drum shaft is threaded through a brass sleeve set in one of the supports; the other end is smooth, and passes through a brass sleeve set in the opposite support.

When the water in the tank is at normal stage, the drum is midway



Emergency work often does not permit searching for tools, or requires that the work be done when the proper tools are not available.

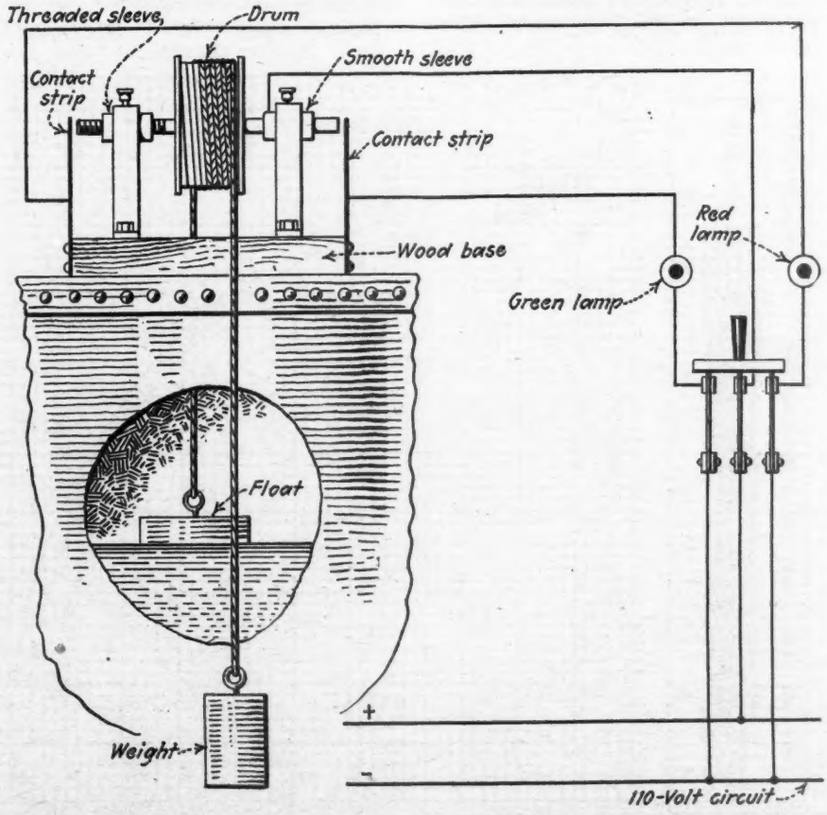
between the supports so that the ends of the shaft stand away from a pair of copper contact strips which project upward from the ends of the varnished hardwood base on which the drum supports are mounted. If the level falls, the drum and shaft rotate as the float lowers. This causes the shaft to advance toward the left-hand contact strip and closes the circuit when the lowest permissible stage is reached. This lights a red lamp which is located in a conspicuous place in the engine room. When the level rises, the drum and shaft rotate in the opposite direction, due to the falling of the weight. When the overflow stage is reached the smooth end of the shaft makes contact with the right-hand strip and closes the circuit through a green lamp which is mounted alongside the red one. The wiring circuit is shown in the accompanying sketch.

The pitch of the thread on the shaft is 0.1 in., the depth from the high to the low stage of water is 62 in. and the diameter of the drum is 10 in. Hence, while the water is rising from the extreme low level to the overflow level, the drum makes approximately two turns and the shaft travels endwise 0.2 in. in shifting from one contact to the other.

A. J. DIXON.

St. Louis, Mo.

Through this float and weight arrangement a red or green signal lamp lights when the water reaches either the low or high limits.



Trouble Caused by Heating of Ferrule-Type Fuses in Single Finger Clips

ON SEVERAL occasions we have had mysterious cases of fuses blowing and in some instances the fiber part of the fuse was carbonized near the end. In two cases we narrowly escaped having a fire; this was prevented only by the fireproof cabinet in which the cutouts were placed. In every case the trouble was found to be incident to the use of inclosed fuses having ferrule contact in single-finger clips.

Careful investigation showed the fuses to be passing current well under their rating. When the fuses were first installed all contacts on both ferrules and clips were thoroughly cleaned, but after the lapse of a week or so the ferrules and clips would commence to tarnish and would get very hot. After this action once started it would grow steadily worse until the fiber tube carbonized and the eventual blowing of the fuses opened the circuits.

The ferrules were found to be circular and the cutout clips happened to be so mounted that they could line up when the fuses were inserted. Apparently the clips had the proper curvature to give the full intended area of contact, but actually such full area of contact is never realized in practice. This was proved in every instance so far tried by simply revolving the fuse a few times, which would cause a scratch, and seldom more than one, to appear on the ferrules, thus showing plainly the actual extent of the area of contact, which was always surprisingly small. The cause of the heating was thus plainly due to insufficient contact area. I improved the contact in one instance by sawing a vertical slot in a clip, thus changing it from the single-finger type to the two-finger type and giving additional points of contact; this reduced the heating considerably, but not quite enough. It is evident that multiple-finger clips should always be used, inasmuch as it is practically impossible to get anywhere near the intended area of contact with the solid or single-finger clip. Otherwise, the ferrules should be made longer or the rating much reduced, or both.

As the result of my experience I can say that I do not care for the ferrule-type fuse, even though it is used with multiple-finger clips, except in cases where the full rating of the fuse is never approached for more than a few minutes at a time. Even then, oxidation will gradually occur and when it is once started such action is rapidly cumulative.

Again, if by chance a fairly good area of contact is realized when the clips are new, it soon diminishes after several insertions of fuses due to the change in the curvature of the clips resulting from springing them apart enough to allow the fuse to enter. Also, after being heated several times the clips lose their temper and the contacts become worse.

At best, I consider such fuses poor devices and a more or less unnecessary fire hazard, and suggest that their use be abandoned, except for the small sizes, 10 amp. and under, and the use of the knife-blade contact type adopted in its place. Even with the knife-blade type of fuse, the full area of contact is never obtained, although it is very closely approximated in the type using the U loop clip as in knife switch construction.

HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.,
Patchogue, N. Y.

Motor Overloaded by Over-Size Impeller in Pump

A TWO-HORSEPOWER, 230-volt d. c. motor, direct-connected to a centrifugal pump had some armature coils burnt out and its journal boxes worn so much that the armature was striking the pole faces. On examining this armature it was found that it was in very bad shape, with the commutator almost completely worn out. The cheapest and quickest way of putting the motor in service again was to put in a new armature and new journal boxes.

After this was done the motor was re-assembled and connected up to the pump. After running about three hours the motor heated up considerably; so a test was made to determine the motor input. The motor nameplate called for 2 hp., 230 volts, 8.1 amp., 1700 r.p.m. A test gave the following results: volts 205, amp. 14, equals 3.86 hp. input. This means that this motor was developing 3.1 brake-hp.

This motor had been in service for over two years and further investigation showed that it had given entire satisfaction for the first 1½ years. At this time a new impeller was put in the centrifugal pump as the old impeller had a badly worn shaft. We were told that ever since then the motor had given trouble in the way of requiring frequent renewal of brushes, and so on. The result of the test showed that this is exactly what would be expected. We also found out that since the new impeller had been installed the motor had been pumping more brine than originally. The results of the investigation thus apparently showed a case of an oversized impeller.

The horsepower required varies as the cube of the velocity. Then $3.1 \div 2 = Vo \div Vn$, where Vo equals the old velocity and Vn equals the new velocity. From this equation it is seen that Vn equals 0.88 Vo.

This means that the diameter of the impeller was too large and, in the case of a shrouded impeller, should be reduced 12 per cent. With an unshrouded impeller, as was the one in question, this value would have to be increased from 3 to 5 per cent. Accordingly the diameter of the impeller was reduced 17.5 per cent. The original diameter was 8 in.; so it was reduced to 6.6 in. When the pump was re-assembled and tested the following results were obtained by test: volts 232, amp. 8, r.p.m. 1610.

The flow of brine obtained after the impeller was turned down was satisfactory, while the horsepower required to do the work did not overtax the motor.

EUSTACE C. SOARES.
Electrical Engineer,
Ophuls & Hill, Inc.,
New York City.

An Easily Applied Graphic Method of Determining Power Factor

THE ACCOMPANYING chart and scale are used to determine the power factor in an industrial plant where the voltage is constant. The system is 3 phase, 480 volts, 60 cycles. The chart can be used for any conditions of balanced load but the scale must be changed to suit the voltage.

In the first column of the scale there is given the apparent kva. In the second column of the scale are the significant figures for corresponding amperes. The scale is based on the equation, kva. = 1.73 × E × I: hence I per kva. is 1.2041, or kva. per ampere is 0.83, for 480 volts, 3 phase.

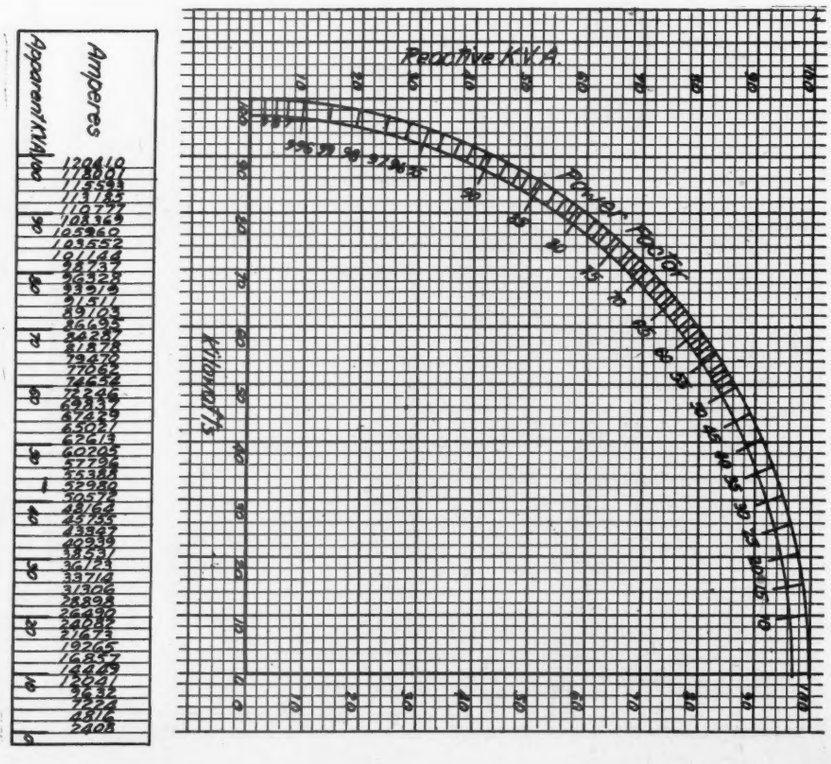
The power factor scale on the chart is laid out with a protractor and reference to a table of cosines, or directly from the scale, as 1,000 kva. on the scale coincides with 900 kw. at a power factor of 90. The chart and scale show the apparent kva., amperes, reactive kva., kw., and power factor all at one setting of the scale. To use this chart, proceed as follows:

Assume that the amperes and kw. are known, as for example, 481 amp. and 360 kw. On the scale opposite 481 amp. we find 400 apparent kva. Now place the zero point of the scale on the zero point of the chart so that 400 kva. cuts the horizontal line corresponding to 360 kw. Reading along the left side of the scale, it will be seen that this setting of the scale gives a power factor of 90. Reading upward along the vertical line from the intersection of the scale and the horizontal line representing 360 kw., it will be seen that the reactive kva. equals 175. The scale and chart can, of course, be used in making calculations of power factor correction when this is accomplished by the use of synchronous motors or otherwise.

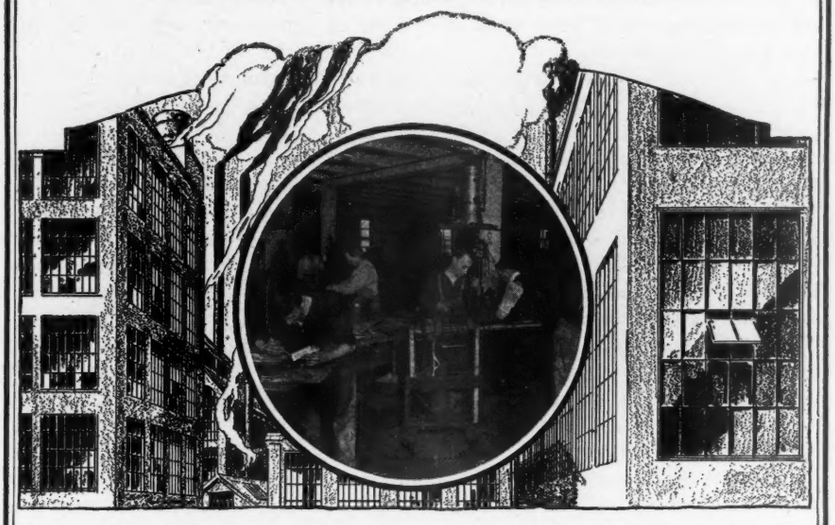
Everett, Wash. W. L. STEVENS.

Power factor can be read directly from this chart and scale.

The load in amperes is found in the second (right hand) column of the scale. The corresponding apparent kva. is then found on the same line in the first column. The zero point of the scale is then placed on the zero point of the chart so that the line of the scale representing the apparent kva. cuts the horizontal line of the chart corresponding to the load in kw. The power factor is then read off on the power factor curve, from the left side of the scale. The reactive kva. are found by reading up along the vertical line from the point of intersection of the line of the scale representing the apparent kva. and the line on the chart representing the kw. load.



In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Iron Ring Useful for Heating Commutator Before Soldering

A PIECE of iron measuring about 2 in. by 2 in. in cross-section and bent in form of a half circle, with the inner radius equal to that of the commutator, has been found very useful by the writer for preheating commutators where a large number of armatures of the same size are constantly under repair. The ring is heated to a red heat and placed on the commutator for a few minutes to warm it up thoroughly. The ring is then removed and the final removal or soldering of leads is done with a soldering iron. It has been found that this speeds up the work considerably, and if care is exercised no damage will be done to the commutator. FREDERICK KRUG.

Comerio Falls,
Bayamon, Porto Rico.

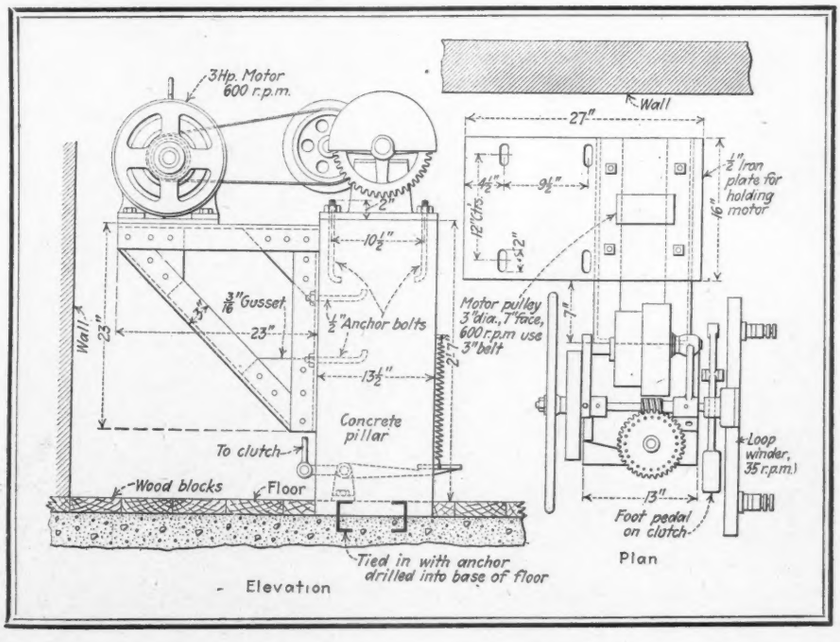
Motor Drive for Coil Winders Saves Overhead Belting

BY MOUNTING the driving motor on the same concrete pillar with a coil-winding machine an overhead belt is eliminated in the repair shop which the writer supervises. The illustration shows the Segur lathe-head coil-winding machine mounted on the concrete pillar. A steel bracket frame was constructed of angles and plates for supporting the motor. This bracket is fastened to the concrete pillar by means of anchor bolts cast in the concrete. The motor is belted to the stepped pulley of the winder and the motor pulley is as wide as the stepped pulley. Belt adjustment is made by means of slots cut in the plate supporting the motor, although a standard adjustable motor base could be used. This drive is not equipped with an idler, as the comparatively small amount of belt pull does not require an idler to prevent slipping.

The motor used is a 3-hp. four-pole, 25-cycle, 440-volt squirrel-cage machine which was reconnected for six poles to reduce the speed from 750 to 500 r.p.m. This gives the proper speed on the winder without using a counter shaft. A welded sheet-metal guard was used to cover the driving mechanism.

Two such winding machines are employed to handle the repairs for about 1200 motors. The cost of the two direct-drive mechanisms amounted to about the cost of the overhead drive with a single motor, and in two years' service has proved far more desirable than the overhead drive, which had been employed.

Electrical Engineer, J. E. HOUSLEY.
Aluminum Ore Company,
East St. Louis, Ill.



Coil winder and its individual motor mounted on concrete pillar.

Reversing Position of Rotor Caused Motor to Heat

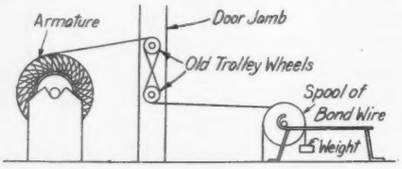
A RATHER unusual condition was disclosed when the writer was recently called upon to locate the cause of heating in a new 10-hp., single-phase, 60-cycle, 220-volt, commutator-type motor. An examination showed that the motor had been taken apart and assembled in such a manner that less than half of the rotor core was running in the stator core. That this was possible is due to the fact that the stator core and rotor core are not in the center of the stator frame but considerably nearer the pulley end. In installing the motor the wiring had been laid out for the shortest length of conduit. The motor was then placed so that the leads were convenient to the conduit, but this made the pulley come on the wrong end of the mo-

tor so the rotor was taken out and put in from the opposite end. With the rotor in this position the magnetic field tended to pull the rotor into the center of the stator, which produced an abnormal end pressure on the front bearing, thereby causing it to heat and grip the shaft. After the bearing had been forced off the shaft and scraped smooth, the motor was properly re-assembled and turned around. After this was done it carried its load quietly and without heating.

A. HERVEY.
New York City.

Easy Method of Putting Tension on Wire When Banding Large Armatures

UNLESS the work can be done in a lathe, banding armatures is at best a rather laborious and time-consuming operation. Many different schemes are used by repair men



The band wire is looped around two small wheels.

for obtaining the desired tension on the band wire, but a method which I have found very satisfactory may be of interest to the readers of INDUSTRIAL ENGINEER. I mounted two old trolley wheels rigidly on a side door jamb and found that by looping the banding wire around them as many times as necessary it was possible to band armatures with very little help. If additional tension is required on the wire, it may be easily obtained by placing a weight on the banding wire spool, as shown in the illustration.

FREDERICK KRUG.
Comerio Falls, Bayamon, Porto Rico.

Transfer Cards for Equipment Keep Records Up-to-Date

INVENTORY systems should tell the location as well as the value, age, make, size, type, and so forth, of every item of equipment in a factory. This information is urgently requested by the fire insurance companies who also recommend making up blueprints showing the various machines on floor or department layouts. In order for the inventory records and blueprint layouts to be of real value, they should be kept up-to-date—in fact, up-to-the-minute. The writer has tried several methods of attaining this end and has finally adopted a transfer card system which has shown very good results in several plants.

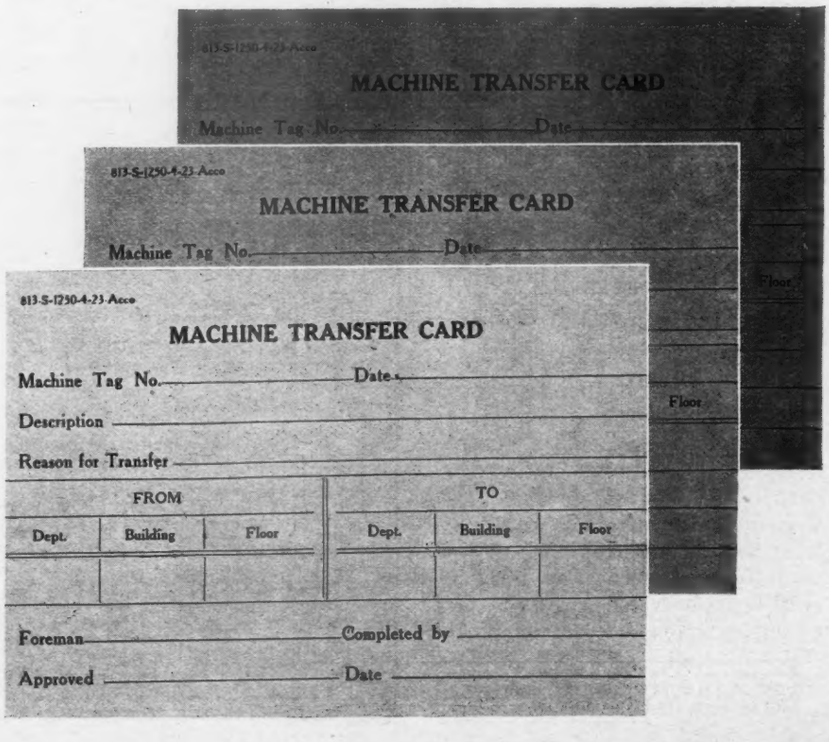
The foreman of each department is instructed by the works manager, superintendent, or whoever is in authority, that no machine or other piece of equipment is to be moved without a transfer card made out and signed by a foreman and countersigned by the works manager. The boss millwright who does the moving and installs the machinery is also given the same instructions. In other words, no machine is moved until a transfer card, properly made out and countersigned, reaches him. The illustration shows the form of transfer card which we use. It could, of course, be varied if necessary to suit conditions in other plants. The cards, which are approximately 3⅜ in. by 5¼ in. are printed on thin paper in three different colors, white, pink, and blue, and are arranged in pads in that order. By the use of carbon paper all three copies are filled out in detail by the foreman in whose department is located the machine to be moved. The three copies are then sent to the works manager, who countersigns them if the move is sanctioned by him. The white copy goes to the millwright who takes it as authority to proceed to move and install the machine in question. The pink copy goes to the cost, or inventory department, and the blue copy to the plant engineer or to whomever is assigned the task of keeping the layouts up-to-date.

After the millwright has completed the job he O.K.'s his copy of the transfer card with his name, and date, and sends it to the plant engineer. Upon receiving it the plant engineer investigates the new location of the machines and shows it on the department layout. After making any notations he may desire on his blue copy of the card, he files it away and forwards the white copy to the inventory department. Thereupon the inventory department makes the necessary changes on their record. The white copy is again forwarded to the works manager and is filed away, completing the cycle for this particular transfer.

In case a new machine has been bought and is to be installed, the boss millwright makes out the cards and sends them to the works manager for approval. On the other hand, it may happen that a small machine, say, a stencil machine or an arbor press, is to be moved and does not require the services of the millwright department; nevertheless, in order to keep the records straight a transfer card should be made out.

D. FLIEGELMAN.
American Chain Company, Bridgeport, Conn.

These cards must be properly filled out and approved before a machine or other piece of equipment may be moved.



Handling Materials

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Increasing Production by Using a Magnet to Load and Unload Cars and Thus Save a Day Between Operations

ONE OF the big advantages of many material-handling installations is that after the equipment is installed it not only facilitates the handling of materials between processes but also, in many cases, enables the process to be speeded up. Sometimes this increase is unanticipated; in other cases the saving is forecast and is one of the direct reasons for introducing material-handling equipment.

Such was the case at the Milwaukee, Wis., plant of the Meynard Steel Company where a 36-in. magnet, as shown in the accompanying illustration, was installed purposely to speed up the production of the annealing furnaces. Originally, investigation indicated that a new furnace must be added to take care of increased production demands. However, further study showed that due to the long periods of idleness between charges, the furnace was not operating as effectively as it might if this idle period could be shortened. Because of the heat it was obviously impossible to unload the charging cars by hand until they had cooled somewhat. Ordinarily four and one-half hours have been required to unload a car; in addition six hours have been required to reload it, making altogether an idle period of ten and one-half hours, or a full day, lost in production. By using a 36-in. Cutler-Hammer (Milwaukee, Wis.) magnet the unloading period was reduced to one-half hour and the loading period to one hour, or a total of one and one-half hours, as against ten and one-half hours. In this way, the operation of the annealing furnaces is practically continuous, as with only one and one-half hours wait between charges the furnace can be filled and put in operation the same day it is unloaded and before it has become cold.

The same magnet handles the hot castings either in loading or unloading cars, or in delivering the castings to tumblers. It is also used to carry the finished castings to the delivery floor and to the trucks. In this way, the magnet not only has increased the production of the furnaces, but it also does a good deal of other handling work in addition.

By decreasing the time between charges—a material-handling problem—production work has been increased without the necessity of an additional annealing furnace.

Through loading and unloading the charging cars for this annealing furnace by a lifting magnet, the idle time between charges was reduced from ten and one-half hours to one and one-half hours. In this way a furnace was back in production inside of a few hours before it had time to become cold instead of being idle a whole day between charges.

Speeding Shipments By a Conveyor System and Special Packing Bench

ONE OF the big problems in most packing and shipping departments is to remove the filled boxes or packages as quickly as possible and with a minimum of effort to the

packer. Often these packages are heavy when filled and are a load if they have to be lifted down from the bench to the floor or onto trucks. In addition, there is the task of trucking, perhaps to an elevator and down to a lower floor, which requires not only considerable time but takes one or more men. In the meantime these boxes are piling up in the way of the packers while they should be removed as soon as the packers are through with them.

Practically all of this lifting and trucking as well as the lowering by elevators is eliminated at the Chicago warehouse of Valentine and Company, varnish manufacturers, by an installation of two conveyor systems. In both warehouses the varnishes and enamels are received in case lots from the factory and stored on the second and third floors. Orders and shipments consist of various assortments of the numerous sizes of cans and colors. In one warehouse all packing is done on the second floor, as shown in the upper of the two illustrations accompanying this item. Orders picked on the third floor, either partially filled or complete, are placed in a box and sent down the spiral chute, shown in front of the window, onto the straight roller section of conveyor in the center of the packing table. The packer pulls the container over to the edge, onto his bench, packs and nails it up. The address and other necessary shipping instructions are stenciled on it and the box pushed onto the roller section again where it is carried down the chute and slide shown in the foreground to the section of roller conveyor and spiral chute shown in the lower of the two illustrations. This section of conveyor was installed by The Dow Company, Louisville, Ky.

The packer can permit the filled boxes to accumulate on the spiral section of gravity conveyor, shown in the lower of the two illustrations, until it is filled to the second floor. Then one of the packers can come to the first floor, remove the boxes and truck them to a section of the floor allotted to freight shipments. Shipments for each railroad are placed together along one wall in a space indicated for them. Each morning these are loaded up by truck and taken to the various freight houses.

The plank platform extending upright over the doorway in the background of the lower of the two illustrations is a drawbridge which may be lowered over a driveway between two buildings or may be used as a platform from which to load trucks.

In the other warehouse, which is about 100 ft. away, packing is done on both the second and the third floors. A switch enables packages from the third floor to be shunted off at the second floor. Here, however, the arrangement is not such that the packages can go direct from the packing bench to the conveyor, but have to be lifted down and trucked across to the opening in the floor. Over 100 ft. of roller conveyor (Mathews Gravity Carrier Company, Elwood City, Pa.) extends from the second floor of this warehouse to the first floor or shipping room of the other warehouse previously mentioned. This conveyor, because it is necessary to leave a driveway, and the yard space between, clear and free from obstructions, skirts the buildings surrounding the yardway and so is necessarily several feet longer than would be the case if it could go directly across. As this section of conveyor between the two buildings is outdoors it is built over or enclosed with sheet-iron which gives it the appearance of a tunnel.

Without these conveyors it would probably require the entire time of one man in each building to load up these boxes on the second or third floor, where they are packed, take them to the elevator, lower them to the first floor and truck them across to the other building. By lowering the cases by gravity conveyors and special chutes, the elevators are reserved for bringing in cases of new stock as received from the factory. Approximately six carloads of varnishes and enamels are received from the factory in case lots each month. These are sent out in many small assortments.

Although about the same number

This conveyor system speeds up the shipment of orders of varnish.

When a man has finished packing a box of varnish or enamel, he simply pushes it over onto the roller section in the center of his packing table and it is carried down to the first floor by the conveyor system shown in the lower of the accompanying illustrations. Here it is distributed to the space allotted to shipments on the various railroads leaving Chicago. Because the packer does not have to give any of his time to removing the packed shipments out of his way he has more time for packing. Orders are picked from the cases in the background or from similar cases on the floor above. All the packing in this building, however, is done on this packing table and conveyor system. Orders are filled in another warehouse some distance away and carried to the same first floor distributing room by another conveyor not illustrated here. This leaves the elevators free for handling incoming stock.

Here the operator handles about fifty tons of coal an hour.

By using a 40½ cu. ft. bucket on this 3-ton hoist a day's fuel requirements of approximately fifty tons are transferred from the hopper, in which they are dumped by the railroad cars, to the storage bunker in about an hour. The out-of-the-ordinary method of mixing the two kinds of fuel by the bucket is explained in the item.

of men are used now as before this system was installed, the volume of work handled is much larger. It is rather difficult to estimate how many men would be required for operating under previous conditions. It is safe to say, however, that more men would be required and also it would be impossible to get the shipments out on such a narrow margin of time as is possible now. This is a most important feature and considerable emphasis is laid on quick delivery, as many dealers order only when their stock is exhausted and they want the shipment immediately.

Handling and Mixing Fifty Tons of Screenings and Coke Breeze in an Hour

HANDLING COAL around an industrial plant is one of the somewhat infrequent or irregular jobs which in many places is now being done by electric cranes and hoists. One of the greatest advantages in this use lies in the fact that with such equipment the large gangs of men which are ordinarily used for this purpose, are eliminated. Also, despite the irregular nature of the work only the operator and perhaps one or two other men are idle during any waits between handlings. These, however, usually can find plenty of miscellaneous jobs to keep them busy for such a short time. Where considerable quantities of coal are used these hoists and buckets are operated economically a large portion of the time. For example, at the Milwaukee Gas Light Company, Milwaukee, Wis., the 3-ton Pawling & Harnischfeger (Milwaukee, Wis.) hoist shown in the accompanying illustration is equipped with a 40½-cu. ft. No. 110 Blaw-Knox bucket for handling coal outdoors. Here the hoist is operated on a 15-in., 50-lb. monorail beam. About 50 tons of either anthracite screenings and coke breeze or Illinois screenings and coke breeze are used under the boiler daily. This fuel is obtained from the local coal stocks on railroad cars and the coke breeze is taken from storage. The fuel is dumped into concrete-lined hoppers beneath the railroad tracks and mixed before delivering to the overhead bunker. Ordinarily mixing would require either a large gang or elaborate equipment. However, in this case it is done by the bucket which picks up the fuel, hoists it and drops it back into the hopper.

Here the action of a bucket is quite similar to mixing by hand. Thus, in a short time the entire lot is mixed evenly enough for the purpose. The hopper capacity is 118 tons while the bunker capacity is 180 tons. Approximately fifty tons an hour are handled by the bucket when working out of the hopper to the bunker. Here the hoist is 45 ft. and the trolley travel 75 ft. The narrow-gage cars shown in the foreground are used to transfer ashes. The hopper is just at the other side of the car.

Using Conveyors for Handling Hot Materials Between Operations or Processes

MATERIALS which are still hot or even too warm to handle offer a type of problem which is quite common in many industries. Pieces which are quite small are frequently handled with a fork or shovel. With larger pieces it is usually necessary to provide some sort of hook to pick them up.

For transfer, conveyors are being used in many plants. Sometimes these conveyors are short—only a few feet in length—to reach from the furnace door to a special lift truck skid. In other cases they are longer and are used to carry the objects needed to the next operation or to a cooling space. One very common use is in carrying the hot case-hardening boxes from the furnace to the quenching tank. In this way one quenching tank can easily handle the work from several furnaces, while the conveyor delivers the box from the furnace to the tanks much more quickly than if the box were closer but had to be lifted across by tongs.

For this work gravity roller conveyors are frequently used, especially if the distance is short. Where the material must be handled some little distance or the pieces are too small to travel on rollers, or the boxes must be elevated, slat or apron conveyors are more frequently used. The use of conveyors not only speeds up the work but also enables one man to do what ordinarily would require three or four. Also, as the man does not have to touch the work by hand, there is much less opportunity to receive serious burns or other injuries.

Shutdowns Have Been Prevented

(Continued from page 287)

The necessary supply of materials for maintenance is kept on hand in the electrical department. These supplies consist of fuses, lamps, and general repair parts of the equipment used. Table II gives a list of the most important spare equipment kept on hand. The department has available approximately 700 hp. in spare motors in sizes varying from the smallest to the largest used. The cost of lamps used per year amounts to about $2,000 and the cost of all other repair equipment is likewise approximately $2,000.

Lock-type lamp guards are used and the keys are kept by the department foreman. All lamps are stamped with the company's name on the globe. A rubber stamp and special ink is used. The stamp was furnished by the Etch-O-Lite Company and Reed glass-etching ink is used.

The department has a good assortment of portable indicating and graphic measuring instruments, which are kept in constant use. These are listed in Table III. These instruments are carefully calibrated by outside parties about three times a year to see that they are in perfect order.

Industrial Maintenance Service

(Continued from page 292)

The size of the form we use is approximately 6x10 inches. These forms are bound in a loose leaf type of binder of rugged construction. A separate sheet is made out for each motor in which a defect is found. The sheets of form No. 1 are taken out of the binder at the completion of inspections and filed until the end of the month when they are used in making up a detailed report shown as form No. 2. This form is made in duplicate, the original sent to the customer and a copy kept on file.

The importance of these monthly reports can not be over-estimated. They serve as a means of showing the amount of attention devoted to equipment and are the guides which customers use in making repairs.

When the confidence of the customer is established in service of this character there is opened up a market for motor equipment in most cases without competition. The profits from this source are an item worthy of consideration, since the selling expense is low.

How to Reclaim Leather Belts

(Continued from page 309)

to scrape down a lap for a joint to an even bevel, and to make sharp edges on the laps.

The author wishes to acknowledge special assistance from Louis W. Arny, secretary, The Leather Belting Exchange; J. R. Hopkins, Chicago Belting Company; F. F. Raniville, F. Raniville Company; H. R. Slivinski, Deering Works, International Harvester Company, Chicago; R. C. Moore, Chas. A. Schieren Company; M. W. Edgar, Detroit Belt Lacer Company, and R. H. Whitney, The B. F. Goodrich Rubber Company, in the preparation of this and other articles which have appeared in this series on belts for industrial purposes.

Editor's Note: Acknowledgment is made to the following companies for assisting in furnishing information and photographs for this and the other articles which have appeared in this series. The Leather Belting Exchange, 119 S. Fourth St., Philadelphia, Pa.; E. C. Atkins & Co., Indianapolis, Ind.; Victor Balata & Textile Belting Co., New York, N. Y.; Birdsboro Foundry & Machine Co., Birdsboro, Pa.; The Bristol Co., Waterbury, Conn.; The Chesapeake Belting Co., Baltimore, Md.; Chicago Belting Co., Chicago, Ill.; Cling-Surface Co., Buffalo, N. Y.; R. & J. Dick Co., Inc., Passaic, N. J.; Detroit Belt Lacer Co., Detroit, Mich.; Detroit Oak Belting Co., Detroit, Mich.; Flexible Steel Lacing Co., Chicago, Ill.; The Gandy Belting Co., Baltimore, Md.; The B. F. Goodrich Rubber Co., Akron, Ohio; The Goodyear Tire & Rubber Co., Akron, Ohio; The Graton & Knight Mfg. Co., Worcester, Mass.; Hide Leather & Belting Co., Chicago, Ill.; Jewell Belting Co., Hartford, Conn.; Laurence Belting Co., New York, N. Y.; Manheim Mfg. & Belting Co., Manheim, Pa.; The Monarch Belting Co., Cleveland, Ohio; New York Rubber Co., New York, N. Y.; F. Raniville Co., Grand Rapids, Mich.; J. E. Rhoads & Sons, Wilmington, Del.; W. H. Salisbury & Co., Chicago, Ill.; Chas. A. Schieren Co., New York, N. Y.; Stanley Belting Corp., Chicago, Ill.; The Strong Machinery & Supply Co., New York, N. Y.; The Taylor Belting Co., Indianapolis, Ind.; United States Rubber Co., New York, N. Y.; I. B. Williams & Sons, Dover, N. H.

A Correction in "Operating Conditions Affecting Belt Service"

THERE IS one point in the second article of the series on belts, "Operating Conditions Affecting Belt Service," in the April issue of the INDUSTRIAL ENGINEER, that I want to particularly call to your attention and which, I believe, you will wish to correct. In the table which you use on page 194, "Minimum Pulley Diameters Recommended for Different Speeds and Weights of Rubber Belts," you show pulley diameters and in the second column give speed in feet per minute, whereas this should be revolutions per minute. However, any analysis of this table considering the figures

This illustration shows one of four 125-hp. induction motors driving compressors. It was originally a 220-volt installation but has been rewound for 200 volts.

given as "belt speed" rather than "pulley speed" will make the whole thing seem ridiculous.

I find that one of the greatest difficulties which we have in giving the average man the right conception of high-speed work is in differentiating between pulley and belt speeds. Of course, as a matter of fact, the actual belt speed, until we get up into very high figures and unusual conditions, is not anything to worry about but the worst of the so-called high-speed, small pulley conditions are encountered where the actual belt speed is probably not over 2,400 ft. per min. From the point of practical application, it is well to consider the pulley diameter and revolutions per minute rather than the linear velocity of the belt. I trust that you will be able to handle this matter in one of your subsequent issues so that it will make the table given appear more reasonable, and I am extremely sorry that I did not make this more clear at the time of sending the table in.

R. H. WHITNEY.

The B. F. Goodrich Rubber Co.,
Akron, Ohio.

Unequal Grouping of Coils

(Continued from page 303)

is, as stated before, the lowest number into which the number of phase groups and the number of slots will each go a whole number of times. In the example shown the number of dots equals 720. As there are twenty poles each horizontal line contains (720 ÷ 20) or 36 dots. Then dividing the total number of dots (720) by the number of slots (144) we get an answer of 5. Thus there are 5 dots for each slot. Therefore every fifth dot is replaced as shown by an *O* which represents one side of a coil. The dots are divided vertically by lines, as shown, into three parts which represent the three phases.

"One side only of each coil is shown in the diagram, the other side is to be taken care of by the pitch-factor.

"The first use made of this 'L. C. M.' diagram was about eight years ago in changing two 750-kw. generators from 25 cycles to 60 cycles. They were originally 32-pole, 94-revolutions per minute, 288-slot, three-phase machines, and they were changed to seventy-six poles, sixty cycles, three-phase using new rotor poles and a new stator winding of 144 coils, but with the old stator core.

"Such induction motors built so far with the unequally-grouped windings have been found on test to have balanced phases when running lightly loaded, loaded and locked.

"The coil connections for a single-primary, two-speed, two-phase induction motor may be readily written out from the two 'L. C. M.' diagrams for the different numbers of poles. A controller for such a motor must do but three things regardless of the number of poles: Leave certain coils in circuit as they were, transfer other coils from one phase to the other without reversal, and transfer the remaining coils from one phase to the other and reverse them. The controller changes for a two-speed, three-phase, single-primary induction motor will be very much more complicated.

"The above form of 'L. C. M.' diagram on section paper will also be found to be very convenient for locating the equal-potential cross connections in multiple two-circuit armature windings as used in direct-current machines."

Trade Literature *You Should Know About*

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

F. Raniville Company, 241-247 Pearl Street, Grand Rapids, Mich.—A circular describes Raniville's "Newply Rebuilt" process for leather belts. This consists of taking usable sections of old leather belting, and putting them through the "belt laundry" where they are cleaned and treated. They are then separated into single-ply belting, the joints opened, and recemented with a piece of new leather on the back, making a double belt. The face of old leather is used next to the pulley with the new leather on the outside to give it strength.

Roller-Smith Company, 233 Broadway, New York City—Bulletin 30 on "Roller-Smith Triplex Ammeter for 3-Phase A.C. Circuits," covers a new type of ammeter recently developed. Among the features claimed for this are that it is possible to take readings of three phases simultaneously by means of three ammeters built in one case.

The Monarch Belting Company, Cleveland, Ohio—A folder entitled "Efficient Belt Transmission" describes the Monarch pulley covering which may be used on steel, cast-iron, wood, fiber or leather pulleys to increase the gripping contact of belts. One of the interesting features of this bulletin is a "Question Box" in which ten questions are asked and answered concerning this covering.

Gund Manufacturing Company, La Crosse, Wis.—A folder describes Gund's adjustable shaft hanger. This is claimed to be adjustable in three ways—in the perpendicular or transversal or on the diagonal—so that a shaft may be placed in the proper position in less time than is ordinarily required.

The Thomas-Smith Company, Canton, Ohio—Catalog 3 illustrates and describes various types of bells for alarm and signal systems.

D. O. James Manufacturing Company, 1114-24 West Monroe Street, Chicago, Ill.—Bulletin 8 contains over a hundred pages devoted to the James speed-reducing transmissions. Numerous sectional and phantom views show the design and construction of the gear and worm speed reducers. A number of pages is devoted to illustrations of installations and to tables giving the ratings of the various types and sizes of reducers.

The Hill Clutch Company, Cleveland, Ohio.—Catalog 8 on friction clutches describes and illustrates the care and operation of The Hill Clutch Pulleys. Instructions for ordering repair parts are included as well as a description and illustration of each separate part, together with its name. Prices for each of the various sizes of repair parts are also included as well as a number of data tables of interest to the engineer.

Smooth-on Manufacturing Company, 570-574 Communipaw Avenue, Jersey City, N. J.—The various uses of "Smooth-on" iron cement No. 7 for making hard, dustproof and oilproof concrete floors, for waterproofing concrete and for oilproofing as well as for repairing holes or cracks in concrete, brick, or stone work, are described and illustrated in a 32-page booklet. A number of out-of-the-ordinary repairs is illustrated.

Square D Company, Detroit, Mich.—Bulletin 30 describes the latest industrial safety switch produced by the Square D Company. This switch embodies several distinctive features, such as unit bases of moulded composition for each jaw and fuse clip instead of the older type slate base. Also, porcelain protective covers enclose each line terminal so that even when the switch cover is open no live parts are exposed. Other features are a positive quick make and break action, as well as an automatic cover control which makes it impossible for anyone except an authorized person with a key to open the cover when the switch is on.

The Service Products Company, Springfield, Ohio—A loose-leaf catalog lists

and describes the various electrical test units and other equipment which this company makes. Much of this is for automotive service station equipment.

Graver Corporation, East Chicago, Ind. —Bulletin 509 describes the Graver "Zeolite" water softener. Several phantom views show the operation of the equipment and a short discussion is included of the chemistry of water-softening.

The Leland Electric Company, Dayton, Ohio—A 4-page bulletin describes and gives prices on the various types of Leland non-stalling, cool-running, 30-deg. motors. These motors are made in from ⅛ hp. to 1 hp. rating. All single phase a. c. motors are repulsion induction and all d. c. motors are compound wound. The bulletin illustrates the eight different types of frames supplied for these motors.

The Electric Welder Company, 327 Permanent Building, Cleveland, Ohio—Bulletin 23 describes the resistance welder Type S. A. F. Dimensions and capacities of the various sizes are given together with the features which are claimed as distinctive improvements for this equipment.

Ashton Manufacturing Company, Newark, N. J.—Circular "B" describes the Ashton "Red-Hot" gasoline fire pot and blow torches. Among the advantages claimed for this firepot is an improved double-needle burner.

The Standard Electric Tool Company, Cincinnati, Ohio—A group of catalogs describes the line of Standard portable electric drills, reamers and grinders for universal, direct current and single-phase alternating current of 60 cycles or less. The grinders are made in portable, pedestal and tool-post types.

The Leonard Electric Manufacturing Company, Cleveland, Ohio—Bulletin J describes the Leonard safety switch and safety power panel. Sketches show the safety features as well as the quick make-and-break and operating mechanisms. The power panels are made up by grouping in a panel board several safety switches.

Aetna Abrasive Company, 1463 West Ohio Street, Chicago, Ill.—A folder lists the various types and grades of Aetna cutting and smoothing commutator stones as well as the use for which they are recommended.

The United States Electrical Tool Company, Cincinnati, Ohio—Catalog 20 illustrates and describes the wide line of United States electrically-driven tools. In this are numerous types of electric drills, drill stands, electric screwdrivers, grinders for using in tool posts of metal working machines as precision grinders or for external or internal grinding, portable surface grinders, as well as electrically driven, direct-connected bench and pedestal grinding outfits.

Burke Electric Company, Erie, Pa.—Bulletin 127 describes the electric arc welding equipment, stationary or portable type, with either electric or gas engine drive. Several pages are devoted to showing types of repairs which may be made by electric welding.

Electro-Service Company, Atlanta, Ga. —A folder describes the Bennett surge arresters, which are claimed to have no fire hazard. The construction and operation are shown and explained by a sketch.

The Divided Pole Electric Company, 2400 Woodland Avenue, Cleveland, Ohio — Recent literature makes announcement of a new type of dynamo electric machine which is to be used as a rotary transformer for transforming alternating current to direct current or from one voltage to another. Some of the advantages claimed for it are its light weight and low cost. It is made in two sizes, 150 amp. and 200 amp., for welding. This folder illustrates the features of construction of the rotary transformer which gives the advantages claimed for it.

Gillis & Geoghegan, 537 West Broadway, New York City—Pamphlet 280 illustrates and describes the equipment used with the G. & G. telescopic hoist to save labor. One of the most common uses of this equipment is for removing ashes through sidewalk openings, although it can be used for many other industrial applications.

The Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Leaflet 2390-A, describes and illustrates the construction of Type E engine-driven alternating-current generators from 50 to 300 kva. These generators are applicable to all prime movers and are suitable for direct connection to steam, gas, and oil engines, or slow speed horizontal water-wheels.

The Hergi Manufacturing Company, 250 Fifth Street, Bridgeport, Conn.—Catalog 17 describes the Hergi flexible shaft equipment especially adapted for grinding and screw driving. One set of grinding attachments comprises twenty-five different grinding tools which are listed and illustrated.

Link-Belt Company, 910 South Michigan Avenue, Chicago, Ill.—Book 600 describes "Link-Belt Material-Handling Equipment for Foundries." Thirty-two pages are devoted to illustrations and descriptions of installations of conveying equipment in foundries. Several drawings show the details of these operations and a careful description shows the production which has been made due to this installation. In addition to the features which are ordinarily found in catalogs this compares in print and picture the practices and methods of six large and nationally-known foundries where by the use of material-handling equipment, production was increased, labor shortage overcome and economies made in time and money—problems which confront every foundryman.

The Thompson Electric Company, 226 St. Clair Avenue, N. E., Cleveland, Ohio—A supplement to catalog B-21 describes the installation methods and conduit wiring features for installing the Thompson system of lamp maintenance hangers. In this system the fixtures are lowered for renewal of lamps or cleaning reflectors thus eliminating all climbing or electrical hazards.

Whiting Corporation, Harvey, Ill.—Catalog 165 on "Whiting Cranes" describes the various types of jib, bridge and gantry electric cranes. In addition to illustrations and descriptions of the principal points of construction of these cranes, considerable space is given to descriptions and illustrations of their use as material-handling equipment.

Chicago Belting Company, 113-125 North Green Street, Chicago, Ill.—A series of circular folders takes up a number of the important features of leather belting manufactured by the Chicago Belting Company. The first of these folders is on the subject of "Identifying Leather Belting Quality"; the second "Tested Leather Belting." Others take up other features of leather and belting.

Watlow Electric Manufacturing Company, 1409 Pine Street, St. Louis, Mo. —A folder describes the Watlow electric box toe steamer, which is used to supply steam for shoe work. It is claimed that this will supply abundant steam of the proper dryness for 10 cents per day, and requires filling with water about once a day.

The Electric Controller and Manufacturing Company, Cleveland, Ohio—A folder describes the type NC 40-deg. motor. One of the features of this is a diagram showing the construction with arrows pointing to special features, which are described.

Canedy-Otto Manufacturing Company, Chicago Heights, Ill.—Catalog 22 describes the line of automotive and other repair shop equipment such as drills, punches, shears, shrinkers, motor shafts, grinders, buffers, forges, blowers, tuyere irons, and other tools. Particular attention is called to portable cranes for lifting work to or from machines or while making repairs.

Acorn Leather and Belting Company, Detroit, Mich.—A small folder lists the advantages of remanufactured belts by the "Neu-Ply" method. This is a process of re-manufacturing and reclaiming leather belting by rebuilding old belt on a new ply of leather.

The Bristol Company, Waterbury, Conn.—Catalog 712 describes the complete line of Bristol belt fasteners. These consist of patent steel belt lacings, belt plates, rivets, flexible wire belt lacing and belt hooks. In addition the size of fastener recommended for each type and size of belt is given.

The Norma Company of America, Anable Avenue, Long Island City, N. Y. —Pamphlet No. 13 entitled "Hoffmann Bearings and Their Use and Influence on Electrical Machinery," describes a number of installations where the Hoffman bearings are used on electrical equipment. These bearings are made in England but distributed in the United States by The Norma Company.

Universal Electric Controller Co., 103 S. Wells Street, Chicago, Ill.—A folder describes the construction and uses of the Universal Electric Controller. This is a potentiometer, resistance device for reducing 110-volt direct current to any desired voltage for operating bells, telephones, fire alarms and other low-voltage signal systems directly from power and lighting circuits. The design of the instrument is such that it shows at a glance whether 110-volt power is on, and also automatically indicates the presence of grounds and shorts in the low-voltage circuits.